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NATURAL HISTORY OBSERVATIONS ON THE AUDUBON COTTONTAIL

BY LLOYD G. INGLES

Although cottontails are among the most widely known of North American mammals, until recently but little has been published on their ecology and life history. The Florida cottontail (*Sylvilagus floridanus mearnsii*) has been reported upon by Trippensee (1934, 1936) and Allen (1938, 1939) both working in Michigan. Hamilton (1940) described the breeding habits of that species for New York state. Bailey (1931) working in New Mexico described briefly the distribution, habitat, economic status, food and breeding habits of three subspecies of *Sylvilagus audubonii*. Grinnell and Storer (1924) likewise dealt briefly with this species in and near Yosemite Park in California. Orr (1940) in his work on the rabbits of California reported more fully than any other worker on the general habits, food and breeding habits, home range and general ecology of the Audubon cottontail. My aim in the present paper is to add to this previously recorded information.

Procedure.—The rabbit considered in this paper is the Audubon cottontail, *Sylvilagus audubonii audubonii* (Baird). The study was confined to individuals living on a tract of 15 acres on the floor of the Sacramento valley, three miles northeast of Durham, California. Most of the observations were made on one part of this tract in an area of about 1½ acres. Scattered observations were made in 1936–37 and in the spring of 1940. Regular observations were made throughout the years 1938 and 1939 except for the summer months (middle of June to middle of September) when irregular observations were made about every two weeks. The area (see map, fig. 1) is intensely farmed; clover, wheat, corn, melons, garden vegetables, peaches, almonds, apples, and berries are grown.

In the two years in which regular observations were made Young and Verbail live traps were employed to catch the individual rabbits that frequented

the various briar tangles. With two exceptions, all the rabbits trapped were taken in Young traps. Because green food was abundant throughout the year it was useless to use bait in the traps. The best results were obtained by placing the traps in the well traveled entrance holes in the closely-knit briar thickets. Dogs, springer spaniels, were used to discover all five of the nests that were studied. When each rabbit was first captured its ears were notched in such a way that it could be readily distinguished with 8 power binocular field glasses from any other differently marked individual. Each individual was given a number and a record was kept of all that was learned

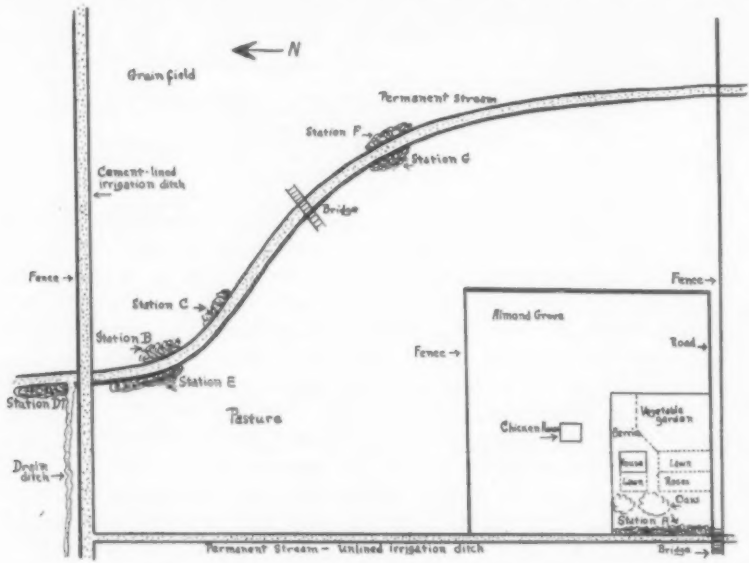

FIG. 1. Map of the area (not drawn to scale). Extreme distance from north to south is 400 yards.

about it from the time it was marked until June 1940. Most of the data were collected by studying these marked individuals with glasses rather than from the relatively few repeats resulting from the continuous trapping at station A and the irregular trapping at the other stations. Between January 20, 1938, and June 10, 1939, except for the summer interval, daily observations were made on the area surrounding station A. The observations were made between 6 p.m. and 7 p.m. and again between 8 p.m. and 9:30 p.m. every evening. Other irregular records were made at other times of the day and night whenever rabbits were seen. A powerful flashlight was used for work at night.

GENERAL HABITS

At station A rabbits were active every hour of the day and night. The low point of their activity is between 9 a.m. and 3 p.m.; many were active,

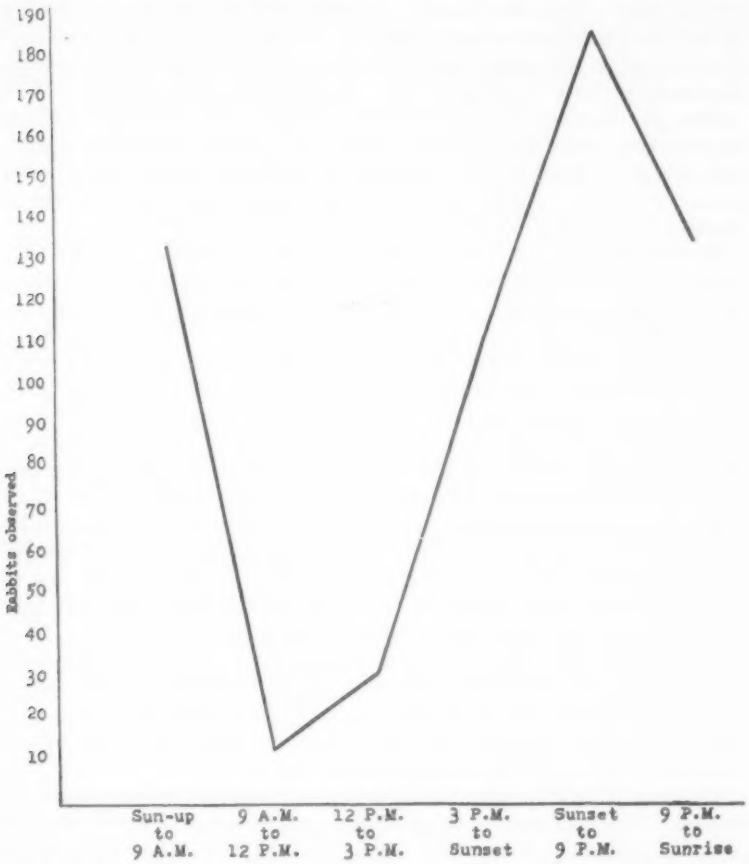

FIG. 2. Showing the distribution of rabbits observed with reference to the time of day at station A. Observations include all that were made from January 20, 1938, to February 29, 1940.

however, in early morning and late afternoon (see fig. 2). At all times of the year the largest number can be observed between sunset and 9 p.m. Decreased activity after 9 p.m. may result from (1) rabbits leaving the vicinity of the station where they congregate in the daylight hours, or (2) the fewness

of observations made after 10 p.m. and before 4 a.m. The data obtained indicate that the rabbits are active throughout the night.

The time of maximum concentrations and greatest activity varies, however, from month to month (fig. 3). In winter the rabbits are seldom seen in the day time. Then they remain concentrated in the various briar thickets because there is little cover anywhere else. As the days grow longer, and with the approach of late spring, rabbits are seen at any hour of the day but most frequently in early morning or late afternoon and early evening. Fewer rabbits are observed about the various stations then, however, probably because they have scattered out among the annual vegetation which is high enough to afford shelter. Probably in the longer winter nights the food requirements of the rabbits can be satisfied without unnecessary exposure in daylight to the hazards of foraging on the relatively bare ground.

Because rabbits can be seen at nearly any hour of the day or night in the spring, data were assembled to discover if there is any marked preference for, or avoidance of, light. This was done by comparing the records of occurrence for clear and cloudy days, and for moonlight and dark nights (fig. 4). The relatively small number of "negative observations" recorded for clear and cloudy days is explained by the fact that these records were made only in the regular evening observation period between 6 and 7 p.m. and 8 and 9:30 p.m. from November 1, 1938, to June 10, 1939, which, of course, means that the daylight records could be made only in the late spring months, since in winter these observation periods always came after sundown.

Of all active rabbits observed in daytime, relatively more are seen on clear sunny days than on cloudy or hazy days. A greater percentage of observations are positive on clear moonlight nights than on dark nights, but the greater ease with which rabbits can be located on moonlight nights introduces a factor of error here which cannot be accurately guaged.

Rabbits often hop about in bright sunlight when the light reading taken from the bare ground measures 650 meter-candles of intensity. By means of a flashlight rabbits have been seen on the darkest nights at a time when human eyes could perceive nothing at all. At night, the tapetum of a rabbit's eye reflects the flashlight rays back as pink.

To learn if rabbits respond to weather conditions, observations were tabulated with reference to times when it rained, when it was windy, and when low temperatures prevailed. A total of 10 rabbits were seen on 6 of the 8 observations made on foggy nights. Fifteen rabbits were observed on 11 of the 22 rainy nights when the animals were sought. There is evidence that they seek shelter when the rain is accompanied by a high wind. At such times a few are seen crouched on the windward side of a tree or other shelter. Eight rabbits were observed in the daytime on 7 rainy days. The animals are active on foggy nights, but are less active on rainy nights.

An attempt was made to discover how the rabbits respond to air move-

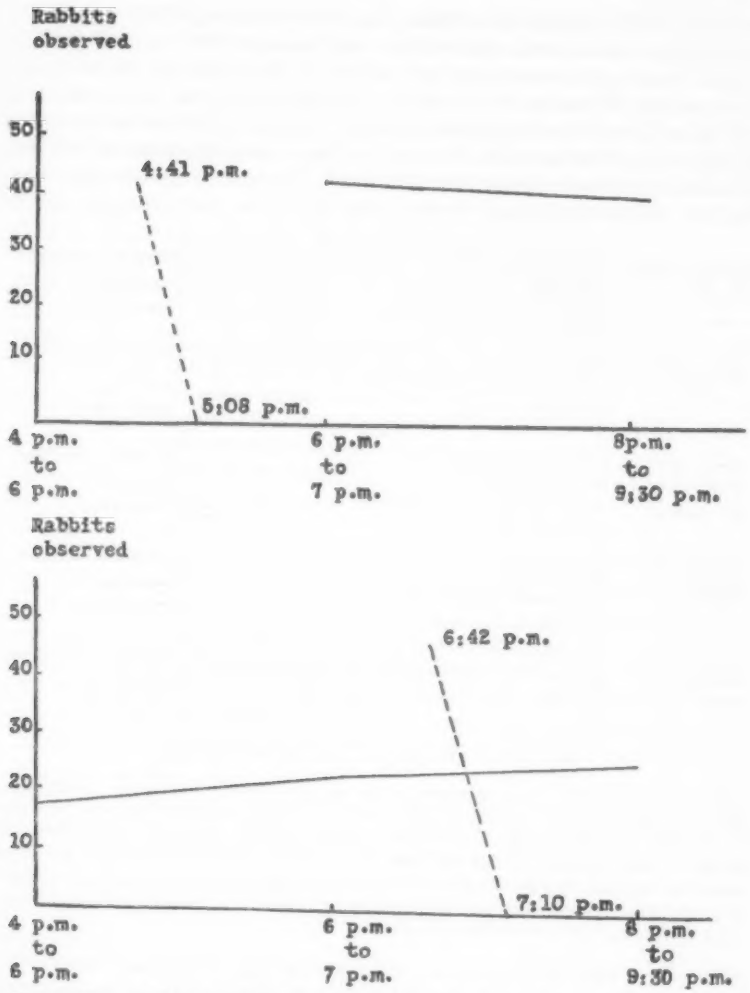

FIG. 3. *Upper:* Time of activity based on three daily observations from December 20, 1938, to January 19, 1939, at station A. Sunset time is represented by the dotted line. Observations were made daily between 6–7 p.m. and 8–9:30 p.m. No rabbits were seen during the irregular observations from 4 p.m. to 6 p.m.

Lower: Activity based on three daily observations from April 20, 1939, to May 20, 1939, at station A. Sunset time is represented by the dotted line. Observations were made daily between 6–7 p.m. and 8–9:30 p.m. Irregular observations were made between 4 and 6 p.m.

ments. "Still" denotes times when there were no perceptible movements of air, "breeze" when the movement of air could be readily felt but not heard, and "wind" refers to movements of air audible in the trees. Of 154 still-night observations 28 per cent were negative, although 197 rabbits were seen during the remainder of the observations giving an average of 1.27 rabbits per observation. On 55 breezy-night observations 36 per cent were negative although 58 rabbits were seen during the remainder, giving 1.05 rabbits per observation. On 61 windy-night observations 34 per cent were negative and 62

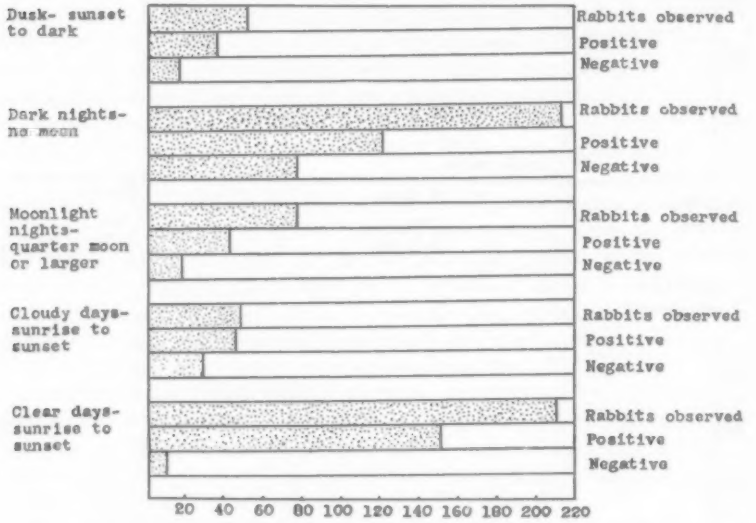

FIG. 4. Rabbit occurrence with respect to light at station A between November 1, 1938, and June 10, 1939. "Rabbits observed" is the total number of animals recorded for a particular type of light. "Positive" is the number of records made when one rabbit, or more, was seen in that particular kind of light during the regular observation periods of 6-7 p.m. and 8-9:30 p.m. "Negative" is the number of records made for a particular kind of light during the regular evening observation periods, between 6-7 p.m. and 8-9:30 p.m., when no rabbits were seen.

rabbits were seen during the remainder giving 1.01 rabbits per observation. Hence it seems evident the animals prefer still nights to those characterized by air movements. This is the reaction that might be expected of an animal that depends so much on hearing for detection of its enemies (see Senses). Temperature data were collected at the time of each regular observation. The temperature ranged from 26° to 100°F in the last part of December 1938, and the middle part of June 1939, respectively. Temperatures as high as 116° frequently are reached in July and August. The rabbits are less active

in the day when the temperature goes above 80°. On several such days they lay on the cool moist lawn and freshly cultivated ground. One rabbit scratched away a little earth to reach the moisture before lying down. While resting thus on hot days, the animals stretched out dog-like with the fore feet extended anteriorly and the hind feet extended to one side of the body.

The reaction of some cottontails to water was observed. They were never seen to drink but they were observed to lick dew drops off grass blades in the early morning hours. The abundance of green food throughout the year probably lessens the necessity for drinking.

The animals swim readily when forced to do so, but whether they will take to water voluntarily is unknown. A mature rabbit (no. 14 ♂) was released from a Young trap in a small pen. The only chance to escape was to swim a 20 foot wide stream that flowed slowly by one side. When the trap was opened the rabbit hopped to the water's edge, halted momentarily, and then jumped quickly into the stream. It swam by rapid strokes, as a dog would swim, to the opposite shore by using its legs alternately. Its progress was about as fast as that of a muskrat, its body floating high in the water. When the shore was reached it took a couple of hops, paused momentarily, then without shaking any water from its fur started off toward station F which was some 50 yards away.

This method of swimming is quite different from that described by Johnson (1925) for jackrabbits and snowshoe rabbits, which propel themselves through the water by a series of hops. Probably these cottontail rabbits depend on swimming and even climbing to escape occasional floods. In December 1937, all ground in the area studied was flooded with at least a foot of flowing water for a period of 24 hours, during which time the nearest exposed ground was about 400 yards distant. In order to escape high water it is believed the rabbits climbed up in the thick berry brambles at the various stations or even on sloping limbs of trees. Sumner (1931) observed an individual that daily rested on a branch of a tree 5.5 feet above the ground. Station A occupies higher ground than the surrounding area and, as a consequence, it is always the last to be flooded. Because rabbits occupied this station previous to the flood and because three were observed there a few days after the water had receded, it is assumed that they must have escaped either by swimming or by climbing.

SENSES

Hearing seems to be much more useful to the animal than smell. The slightest sounds proved sufficient to cause timid individuals to stop feeding for minutes at a time. The sense of smell seems to be poorly developed. A photographic blind was set up one day near some fallen green peaches on which the rabbits had been feeding. After they became accustomed to the blind, the author stationed himself in it one morning before sun-up. After

an hour a cottontail was seen to leave station A and hop leisurely down the road toward the blind, pausing a few times as it approached. All of the peaches had been removed except two, which were within 3 feet of the camera, and to these the animal came, apparently unaware of the close proximity of a human being until the shutter clicked. It then hastily retreated. The rabbit's eyes are well adapted to pick up movements even as small and as far away as a dog appears at 100 yards. They seem unable to distinguish a potential enemy if it remains quiet unless it is very close. The author observed a cottontail approaching him on a path one evening about dusk. He stopped to allow the rabbit to approach. It did so to within 15 feet before it recognized that something obstructed the path. It paused for a few seconds, detoured around, and entered the path again closer to its goal. Since certain foods are preferred it is assumed the sense of taste is well developed.

HOME RANGE; COVER

The extent of the home range of the Audubon cottontail on this area is determined by the almost impenetrable clumps of blackberry brambles and by the relative height of the herbaceous vegetation. Practically all of the feeding was within 75 yards of one of these briar patches (stations on the map, fig. 1) and never more than 150 yards from such relatively permanent protection. The east side of station A (fig. 1) was the place where at least 2 and never more than 5 rabbits foraged regularly at different times. Other rabbits occasionally occurred with them at irregular times, which fact, together with the trapping records (table 1), indicates some degree of traveling from station to station, particularly by certain males. The home range of a male rabbit may be as much as 15 acres since 3 were taken at stations 400 yards apart. The home range of a female rabbit is often less than an acre, which may be shared with as many as 4 other rabbits. Dalke and Sime (1938) found the females of *Sylvilagus floridanus* to have a range extending over 3 acres and the males with a range of about 8 acres. Trippensee (1934) found the average home range of the same species to be one acre, whereas Allen (1939) found that the home range averaged 3.6 acres for males and 2.2 acres for females.

In this part of the range of *Sylvilagus audubonii* the animals rarely use holes, forms, or any other cover than the thick brambles. In this study only one rabbit was started from a form which it was known to occupy for about a week. This was hardly a form in comparison with those made by the above-mentioned eastern cottontail or the western jackrabbit (*Lepus californicus*). It consisted merely of a large star thistle (*Centaurea solstitialis*) that was growing close to a board fence. The rabbit hid itself in the little tunnel between the thistle and the lower board. Although numerous ground squirrel burrows were present in the almond grove and grain field, no rabbit was seen to enter them nor could tracks or other signs be found near the holes at any time. Grinnell and Storer (1924) and Orr (1940) found this species frequently

occupying holes and forms in other parts of its range. It seems that where both holes and berry thickets are present the latter are always preferred.

There is little evidence of trails from their refuges to the feeding grounds. In winter when the herbaceous growth is low, they forage or play on nearly

TABLE 1.—*Showing history of marked rabbits from February 24, 1938, to May 30, 1940*

NUMBER	SEX	MARKED	LAST OBSERVED	MONTHS OBSERVED (OR PART OF)	TRAP REPEATS	NUMBER OF TIMES OBSERVED	KNOWN STATIONS FREQUENTED	AGE WHEN MARKED
1	♀	2/24/38	9/ 1/39	19	4	85	A	Mature
2	♀	2/26/38	4/ 5/38	2	1	2	A	Mature
3	♂	3/ 7/38	3/ 2/39	12	0	7	A	Nearly mature
4	♂	4/10/38	1/22/39	9	2	7	A	Mature
5	♀	4/14/38	3/29/39	12	2	57	A	Mature
6	♂	5/ 7/38	1/17/39	8	1	1	A–D	Mature
7	♂	5/ 8/38	6/ 3/39	13	7	25	A	Mature
8[1]	?	5/28/38	5/28/38	0	0	0	A	Young
9	?	5/28/39	6/ 8/38	1	1	2	A	Young
10	♀	6/ 4/38	12/ 4/38	6	1	12	A–B	Young
11	♀	11/27/38	11/26/39	12	4	7	A	Nearly mature
12	?	11/29/38	12/19/38	1	2	4	B	Young
12A[2]	♂	12/ 4/38	4/28/40	16	4	34	A–B–D–E	Mature
13	♂	12/ 7/38	5/13/39	5	1	2	A	Mature
14	♂	12/ 9/38	5/17/39	5	3	4	A–C–D–F	Mature
15	♂	12/10/38	12/16/38	0	2	2	A	Half grown
16	♀	12/11/38	5/13/39	5	2	41	A	Mature
17	♀	12/17/38	5/ 9/39	5	3	13	A–D	Mature
18	♂	1/16/39	2/ 4/39	1	0	5	A	Mature
19	♂	2/19/39	3/21/39	1	2	12	A	Mature
20	?	3/25/39	3/26/39	0	1	1	A	Young
21	?	3/25/39	3/25/39	0	0	0	A	Young
22	?	3/25/39	3/25/39	0	0	0	A	Young
23	?	3/25/39	3/25/39	0	0	0	A	Young
24	?	3/27/39	3/27/39	0	0	0	A	Young
25	♂	4/15/39	11/12/39	8	3	4	A	Young
26	♀	5/ 7/39	5/ 7/39	0	0	0	A	Half grown
27	♀	5/29/39	5/28/40	12	2	19	A	Two-thirds grown
28	♀	2/29/40	5/30/40	3	0	5	A	Two-thirds grown

[1] Accidentally killed on the same day.

[2] The ears of this rabbit were marked like no. 12 when the latter was known to be dead. (See Predators.)

any open space within 75 yards of one of the stations. In the spring as the vegetation grows taller, they abandon these favorite feeding spots for those with shorter cover. There is some reason to think that they disperse from the stations during the summer when the herbaceous plant growth is heavy.

Their absence may be more apparent than real, however, because they are harder to see at this time of the year.

ENEMIES

Some animals known to prey on cottontail rabbits and known to live on this area since they were seen there in the course of this study are gopher snake (*Pituophis catenifer*), rattlesnake (*Crotalus oregonus*), marsh hawk (*Circus hudsonius*), and domestic dogs and cats. Other predators identified either by calls or by tracks are horned owl (*Bubo virginianus*), barn owl (*Tyto alba pratincola*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), and mink (*Mustela vison*). In spite of the relatively large number of species of predators frequenting the area, only one of the marked rabbits is known to have lost its life due to predation. This young rabbit (no. 12) had been out of the nest only 20 days when one hind foot and its marked ears were found 52 yards from station B where it was known to hide. The predator captured the rabbit in the night on a trail that leads through the deep grass. It was eaten on the spot.

Two rabbits were observed in mid-winter while a couple of horned owls were hooting in the oaks near station A. Once the owls were actually within fifty yards of four rabbits that continued to feed in the open from 3 to 15 feet from the closest cover. Efforts were made to see how the hoots of the owls affected the rabbits but unfortunately all activity ceased when the flashlight beam centered on the rabbits. On another night a yelping coyote near station D seemed to have no effect on two rabbits feeding near station A. It is believed that a mink attacked a rabbit (no. 14♂) as it was safely held in a Young live trap at station D on December 9, 1938. The trap containing the rabbit was turned over and moved somewhat from the place where it was set. Large mink tracks were found along the stream near-by and there was an egg-shaped tear in the rabbit's skin which measured 1 x 1½ inches. One month later when this rabbit was recaptured the wound had completely healed but was sparsely haired.

ESCAPE BEHAVIOR

That young rabbits in the nest have an odor which may betray them to predators seems likely, since all 5 nests discovered were found by the use of dogs. Two springer spaniels were freed from their pen each morning and late afternoon for from 1 to 3 hours. The presence of these dogs seemed to have little effect on discouraging or driving the rabbits from station A even in spite of the fact that they were chased by the dogs almost daily. On no occasion did these dogs ever catch a rabbit, although at least twice the rabbits were closely pressed. One of them had been out of the nest but five days, and it barely escaped in some Oregon grape (*Berberis aquifolium*) after a fifty yard run. Another time a full grown male rabbit that had just been trapped at

station A was released some fifty yards away and some distance in front of the two dogs. Instead of going directly toward the berry thicket (A) it circled about the shrubbery and trees, passing within 15 yards of the thicket, yet not entering it in spite of the desperate nature of the chase. This was taken to indicate that the rabbit was unfamiliar with the cover about the station and probably had arrived there only recently. It successfully eluded the dogs by dodging sharply on three occasions when close pressed.

As noted also by Orr (*op. cit.*), these cottontails take advantage of the warning calls of certain other animals. One morning a mature rabbit (no. 16 ♀) was watched as it was nibbling grass close to station A. A large flock of Gambel (*Zonotrichia leucophrys*) and Golden-crowned (*Zonotrichia coronata*) sparrows were feeding near the station. When the birds became alarmed they flew hurriedly into the briars. Each time they did this the rabbit dashed for the same cover but stopped just outside to listen for several seconds before moving about again.

The tail of the rabbit was watched particularly to see if it played a significant part in the animal's escape behavior. It was noted that (1) the tail is raised, exposing a maximum amount of white, as the animal runs after an alarm, (2) the tail is carried pointing toward the ground, exposing a minimum amount of white, when the animal feeds or hops leisurely. Because these methods of carrying the tail were observed many times it is believed the organ might be useful in eluding a predator as the rabbit runs before it. Perhaps the white cottony tail is conspicuously bobbed ahead of the pursuer until the instant when the rabbit dodges to one side thus enabling it to escape a predator by confusing it temporarily. The above-mentioned dogs frequently completely lost sight of their quarry after it dodged quickly to one side. Certainly at night or in dim light this white fluffy tail can be readily seen when no other part of its body is visible as the animal runs away.

Another method of escape that is frequently used by rabbits is "freezing." Cushing (1939) says, "The rabbits themselves place no reliance upon freezing as a protective device when alarmed." Ample opportunity was provided in this study, however, to observe the manner in which freezing was accomplished and how it succeeded in preventing the rabbit from being detected. It is true that rabbits will not rely upon freezing if their enemies come too close (perhaps closer than ten feet) but there is no doubt that they use it effectively to escape detection when they see or hear a potential enemy that is farther away. Many times the writer has approached to within 15 feet of "freezing" cottontails before they ran for cover. Generally on such occasions if the animals are not started from their "freezing" position, they dash for cover as soon as the danger has passed. The following example illustrates this behavior. One day the writer was standing in a road observing two rabbits (nos. 12 A ♂ and 16 ♀) as they were feeding about thirty feet away. The female was out on the ploughed ground about two feet from the high Johnson

grass in which the male was feeding. A strange dog approaching from down the road stopped before reaching the writer, barked once, and then detoured within ten feet of the exposed rabbit. When the rabbit first sighted the dog it squatted close to the earth with its neck and head extended along the ground. It remained in this position until the dog had passed, then leaped hurriedly into the tall grass. The other rabbit likewise had "frozen" when the dog barked. Hence it appears that freezing is frequently successfully employed to elude a possible enemy.

On one occasion only was a rabbit's voice heard—when a mature cottontail caught by the hind legs was pulled from a Young trap. The squeal lasted only a few seconds. This rabbit also attempted to bite as it was being taken from the trap, another trait of behavior not again observed.

PARASITES AND DISEASE

Each time a rabbit was trapped, it was carefully examined for external parasites, larval cestodes, and fly warbles. Only one parasite, a species of flea (*Spilopsyllus*) was found. Jackrabbits (*Lepus californicus*) from this area yielded larvae of *Cuterebra* and the cysticerci of an unidentified tapeworm. A species of *Cuterebra* is known to parasitize woodrats (*Neotoma fuscipes streatori*) close to station D, and although *Cutebra leporivora* is reported from California cottontails (Hall, 1921) none was found on the rabbits examined during this study. No attempt was made to examine the animals for internal parasites other than those that might be beneath the skin. No sick rabbits were discovered. A tick, *Haemaphysalis*, is known to be a carrier of tularemia, but was never found on rabbits in this area.

FOOD

Considerable attention was given to the food of the Audubon cottontail. The streams and canals which border all of the stations (fig. 1) are permanent and green herbaceous plants are always plentiful near the water, even during the dry summer and autumn months. Practically all of the arable land is irrigated throughout the summer and many kinds of green plants are accessible there. This year-round supply of green food may account for the differences in food preferences of the rabbits on this area and rabbits in other parts of California. Plants readily eaten in the area studied are: Johnson grass (*Holcus halepensis*), Bermuda grass (*Cynodon dactylon*), Blue grass (*Poa pratensis*), ripgut grass (*Bromus rigidus*), wheat grass (*Agropyron caninum*), morning glory (*Convolvulus*), bull mallow (*Malva borealis*), honey suckle (*Lonicera*), chick weed (*Stellaria media*), red stemmed filaree (*Erodium circutarium*), and sow thistle (*Sonchus asper*). Also cultivated hollyhock, carrots (when pulled), acorns of the valley oak (*Quercus lobata*), and the fruit of the almond and peach are occasionally eaten. No rabbit was seen to eat from any shrub nor is there evidence that the various wild and cultivated shrubs

and trees are eaten in this area. In other parts of California Orr (*op. cit.*) reported that this species of cottontail ate a number of shrubby plants and was particularly fond of the wild rose (*Rosa californica*).

Two individuals caged for about two weeks (nos. 18♂ and 19♂) were provided with freshly cut twigs of apple, apricot, almond, peach, raspberry, and fig. In the outdoor cage also were naturally growing ripgut grass, red stemmed filaree, sow thistle, chickweed and bull mallow. The herbs were in some cases eaten to the ground but none of the shrubby plants was touched. This was in January when herbaceous plants are green but still low. Around these stations the animals show more preference for the introduced weeds and wild grasses than they do for cultivated plants. The rabbit cuts its food free then proceeds to eat it basal end first. This applies even when the leaves of plants are eaten.

To find out how much of the preferred food is eaten in one night, the growing herbs in the cages of both of the above-mentioned rabbits were covered with a large canvas. Carefully weighed amounts of various plants were placed in each cage and at the same time samples of each plant were placed in a container just outside the cage so that loss from evaporation could be ascertained. The feeding experiments for the two rabbits began at 5 p.m. on January 27, 1939, and lasted for fifteen hours. In this period of time rabbit no. 18♂ ate a total of 171 grams of food and rabbit no. 19♂ ate a total of 209 grams of the same kinds of food. This food consisted of ripgut grass (*Bromus rigidus*), bull mallow (*Malva borealis*), sow-thistle (*Sonchus asper*), red-stemmed filaree (*Erodium circutarium*), chick weed (*Stellaria media*) and blue grass (*Poa pratensis*). The total amount eaten in both instances by these Audubon cottontails is considerably more than the average amount of food eaten by the larger Mearns cottontail (*Sylvilagus floridanus mearnsii*) in Michigan, which amount is given by Trippensee (1934) as 55.2 grams of solid food daily.

Fecal counts were made with the two caged individuals used in these feeding experiments. After the fifteen hour period one rabbit (no. 18 ♂) left 448 pellets weighing 29.2 grams. It had urinated twenty times. The other animal (no. 19 ♂) left 540 pellets weighing 26.5 grams. There were seventeen urinations. The pellets are ellipsoidal and the average of ten was 7.1 mm by 4.8 mm. These cottontails did not regularly defecate where they habitually rest but did so as they hopped about the cage and while eating. Rabbits at liberty have been observed to do likewise. Hence little piles of pellets so characteristic of the eastern species (*Sylvilagus floridanus mearnsii*) are absent around the different stations. The number of pellets for the Mearns cottontail averages 265 per day, which weigh 20.8 grams (Trippensee, *op. cit.*). Only three urinations per day are given as an average for that species by the same worker.

BREEDING BEHAVIOR

Of 29 animals examined as to sex, 10 were females, 11 were males, and 8 were too young to sex with certainty. Whereas these figures indicate a nearly equal number of each sex, Trippensee (*op. cit.*) found that only 43 per cent of the 216 individuals of the Mearns cottontail examined by him were females. He suggests that this seeming differential may result from the holing tendencies of the females in shooting periods and to a greater inclination of the males to enter traps. This latter suggested inclination is likewise indicated with the Audubon cottontail (Table 1) for 10 females repeated in traps a total of 19 times, whereas 11 males repeated a total of 25 times. The numbers here, however, are probably too small to be significant. Out of the hand the sex of an individual could not be distinguished. When captured the sex could readily be determined in all adults by an examination of the genitalia. By applying slight pressure on either side of the genital opening the organs are easily exposed (Fig. 5). The penis is more cylindrical with a much smaller groove running along its length than is the clitoris. Frequently this examination is unnecessary if the animal is a male because the large testes are generally in the scrotal sac. Between November and May the testes were always found in the scrotum of mature individuals.

Frequent opportunity was had to compare the behavior of marked individuals of known sex with other marked individuals. In the winter and spring, 1939, station A appeared to be the permanent abode of Nos. 12 A ♂, 1 ♀, and 16 ♀. Two and sometimes all three rabbits foraged close together. There was no evidence of antagonism between these two females or between any other females even when sharing the same square yard of feeding ground. Occasional visitors to station A during these same months were Nos. 6 ♂, 7 ♂, and 14 ♂. These last mentioned males all appeared in the traps or were observed on the area within the same two or three day interval. Possibly they were attracted by one of the females in sexual heat. The females were as indifferent to these visiting males as they were to the resident male rabbit. Among the male rabbits there was little harmony or toleration. This was first noticed when the resident male rabbit was not observed during the same three days when no. 7 ♂ appeared suddenly and was known to be visiting at station A. Later, on two separate visits, no. 7 ♂ was seen to chase no. 12 A ♂ entirely away from this station. Likewise no. 12 A ♂ was seen to chase no. 14 ♂ away from station A in a manner typical of the way one male rabbit deals with another attempting temporarily to occupy the same station. The following notebook record of behavior of these last-mentioned males was made: "May 17, 1939, 6:30 P.M. warm, cloudy, south breeze. Saw no. 14 ♂ in the road just outside of the rose garden. At nearly the same instant no. 12 A ♂ (the male regularly seen here) was observed to leave station A and to hop straight down the road (about fifty yards) to within two feet of no. 14 ♂. Both rabbits sat quietly for about a minute after which no. 14 ♂ began to hop slowly down the road but steadily accel-

erated his speed as no. 12 A ♂ began pursuit. Both rabbits stayed about one yard apart until they reached a point about 150 yards from station A where-upon they turned sharply to enter the tall grass in the almond grove and were lost from sight temporarily. Shortly no. 14 ♂ was seen sneaking along like a whipped dog just ahead of no. 12 A ♂. They made a wide circle and when no. 14 ♂ entered the tall grass across the road from the almond grove no. 12 A ♂ stopped, licked its paws, then hopped leisurely back to station A."

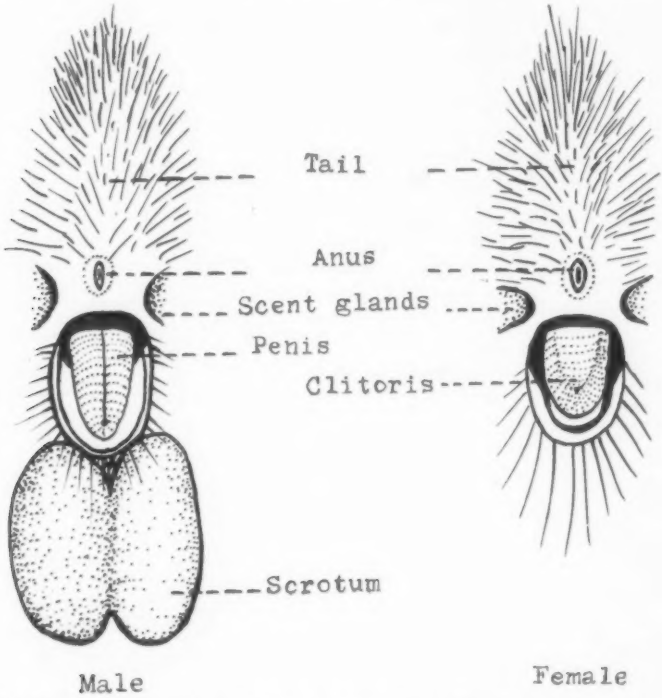

FIG. 5. Showing the differences in shape of the external genitalia (somewhat enlarged in comparison with other structures shown) of adults of both sexes.

There is some other evidence that rabbits occasionally fight each other although they were never seen in actual combat. Twice near station A large pieces of rabbit fur were found scattered over an area about ten feet in diameter and smaller bits of fur lay about for a linear distance of fifty yards. No skin or blood was on this fur. Therefore, it seems unlikely that the scattered fur was left by some predator. Possibly the fur marked the scene of a fight between rabbits the previous night.

The females seemed to be compatible for there was seldom a time that

station A did not harbor at least two. Indeed four females (nos. 1 ♀, 5 ♀, 16 ♀, and 17 ♀) were known to occupy station A on March 16, 1939.

It seems that the breeding season extends throughout the year on this area. Pregnant females, lactating females, and young in the nest have been found in every month except January, July and October. Orr (*op. cit.*), working farther south, found a shorter breeding season which included at least those months from December to June. The peak of breeding activity was in April.

The number of litters per year is unknown. Orr (*op. cit.*) thinks that in many instances there may be more than 2 litters a year. He gives the average as 3.6 with extremes of 2 and 6 per litter. In New Mexico Bailey (1931) found that 2 females of *Sylvilagus audubonii cedrophilus* each had 2 embryos. Three pregnant females of *Sylvilagus auduboni* and 3 nests examined by the writer indicate a litter size of 3, with a range of from 1 to 5. Hamilton (1940) gives 4.5 per litter for the cottontail (*Sylvilagus floridanus*) in New York state and Trippensee (*op. cit.*) gives 5 as the average per litter for *Sylvilagus floridanus mearnsii* in Michigan. Also in Kalamazoo County, Michigan (Allen, 1938) gives 5.1 as the average per litter for the same species. It is clear from these reports that the *audubonii* group has fewer young per litter than the eastern species. It is felt, however, that the longer breeding season of the western rabbits compensates for the smaller litters; they may have 2 or even 3 litters as against one in the Eastern United States.

NESTS

With the aid of two springer spaniel dogs 5 nests were discovered, 3 of which contained young rabbits (Plate I). These nests were all made in pear-shaped excavations in the ground from 6 inches to 10 inches deep with a 6 inch diameter across the largest (near the bottom) part. In one nest the entrance was only 2 inches in diameter and the nest was 10 inches deep. This raises the question of how the excavation was made. In all five nests the axis of the excavation was inclined toward the north. Each was first lined with a thick layer of fine grasses and dried weeds then the inside was entirely filled with rabbit fur. It was in this fluffy mass of fur that the young reposed.

Nest no. 1 was discovered under the house on June 5, 1938. It included in the outer grassy layer burlap shreds and a layer of green grass between the fur and the outer layer. This green grass had to be transported at least 20 feet. This nest contained one very young rabbit described later in this paper.

Nest no. 2 was discovered under a spreading star thistle (*Centaurea solstitialis*) on November 29, 1938. It was 30 feet from station B in the open field. The three young rabbits ran from the nest when the dog began pawing at the opening. They could not be induced to remain in the nest again, so they were marked and released.

Nest no. 3 was discovered in the open on the north side of a bank bordering

PLATE I

Above: The nest of the Audubon cottontail under an occupied house. The nest contained one young rabbit (no. 10 ♀).

Below: An Audubon cottontail (no. 10 ♀) approximately six months old.

the irrigation ditch 30 feet from station D. It was found by the dogs on December 19, 1938. It was built in the center of a place where a pile of brush had been burned on November 28, 1938, and gave some evidence of having been disturbed by a predator a day or two before it was discovered. Whether this occurred before or after the young rabbits left the nest is not known.

Nest no. 4 was located in the open under the oak trees about 40 yards east of station A on March 25, 1939. The 4 young rabbits had apparently just left the nest since they were all located from 20 to 40 feet away hiding under various kinds of cover. The nest was in an area that was regularly flooded by irrigation each summer. This nest was carefully excavated; the dead leaves, grass, and fur with which it was constructed weighed 60 grams.

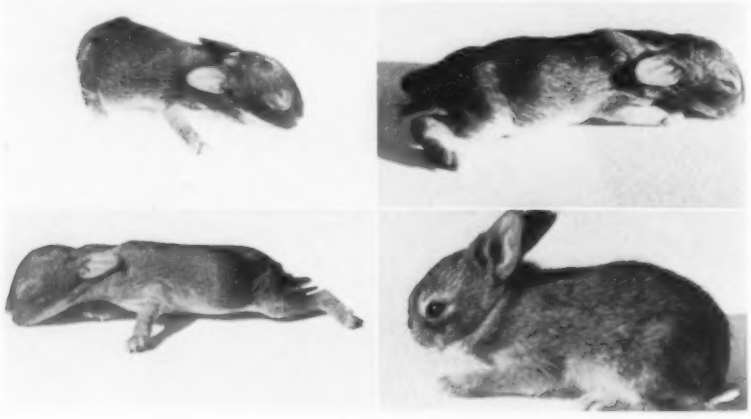

PLATE II

Upper left: Young Audubon cottontail (no. 10 ♀) approximately four days old (measurements in text).

Lower left: Same approximately four days old.

Upper right: Same approximately seven days old.

Lower right: Same approximately eleven days old.

Nest no. 5 was discovered under the garage on October 1, 1939. It had not been occupied for some time.

The behavior of the very young rabbit in nest no. 1 was studied carefully during the time it remained in the nest. A blind was constructed 12 feet from the nest and although many hours were spent watching the mother never came near while the blind was occupied. Female no. 5 was observed frequently in the rose garden, lawn, and garden during the time the young one was in the nest and there is little doubt but that she was its mother. Female no. 1, which was occupying station A at the same time, was never seen as

close to the nest as these near-by places which were regularly frequented by no. 5 ♀.

Unfortunately no scales were available during the time the young rabbit in nest no. 1 was being observed, hence its weight was not obtained. The young rabbit was removed from the nest every other day, however, to be photographed, measured and its behavior noted. These measurements were made on the day the young rabbit (no. 10 ♀) was discovered and at four day intervals thereafter. On June 4, 8 and 12 the total length in millimeters of the young rabbit was 90, 120 and 140 respectively. Other measurements on these days were: ear 15, 17 and 25 millimeters respectively; tail 10, 15 and 15 respectively; and hind foot 18, 25 and 35 millimeters respectively. Trippensee (*op. cit.*) records the average measurements of 9 young *Sylvilagus floridanus mearnsii* that were stillborn to a captive female as: weight 32.8 grams, length 117 mm, foot length 12 mm, ear 13 mm, and tail 12 mm.

The greater length of the foot and ear in the smaller western species is interesting since they are so much longer than the foot and ear of the stillborn eastern species. This young rabbit (no. 10 ♀) could hardly have been more than a day or two old when it was discovered, judging from the fresh green grass with which the nest was lined and by the short piece of umbilical cord 2 mm long which still persisted. The hair was very sparse and nowhere was it over 2 mm long. Hair on the back and on the head was only perceptible. The skin on the back and sides was lead colored changing to pink on the ventral surfaces. It was very wrinkled on the back of the head. Its eyes were tightly closed. There was no light spot on the forehead as there is in the young and juveniles of the eastern species; however, there was a suggestion of such a spot the next day but it disappeared entirely after 6 days. The young rabbit could find its way back into the nest on the day it was found if it were placed with the fur of the nest touching its nose (Plate II).

During the second day after its discovery an interesting reaction was observed. When the hair over the opening of the nest was touched, even very lightly, the young rabbit lunged upward and at the same time uttered a *qupp* sound somewhat resembling the removal of a cork from a bottle. This was repeated every time the hair on the nest was touched and was the only sound the young rabbit was ever heard to utter. This sound is interpreted as a call response preparatory to nursing. The assumption is that the mother in crouching over the nest would move the exposed fur lining on the top of it, and the stimulus would evoke the above-mentioned response which would sooner or later bring the young cottontail in contact with the teat. It was discovered that while a person occupied a blind 12 feet away the parent would not approach the nest. Hence in order to test this assumed method of feeding the young animal, a one inch layer of fine dust was spread over a radius of about a yard away from the nest in all directions. Tracks in the fine dust subsequently showed clearly how the mother merely crouched over

the nest while the young nursed. By keeping the dust spread evenly around the nest and observing it frequently at a distance it was demonstrated that on one occasion the young rabbit was fed between 1 and 2 p.m. after at least a 31.5 hour period had elapsed since the previous feeding. On another occasion it was fed at 8 p.m. after at least a 30 hour period had lapsed. Five or six days after the young rabbit was found it almost crawled out of the nest when the hair covering it was disturbed even so slightly as by blowing the breath on it. Especially was this true if the youngster had not been fed for several hours.

Nine days after its discovery the young rabbit jumped entirely out of the nest each time the hair was touched. On this same day its left eye began to open. It was then ear-marked and returned to the nest. The next morning (10 days after its discovery) it was still in the nest. Both eyes were open; it could now hop slightly. The writer was then unfortunately called away for 4 days, and when he returned the young rabbit had left. It was occasionally seen about the yard for the next three weeks then disappeared only to find its way into a Young live trap at station B on December 4, 1938. At this time (age 6 months) it was fully mature and milk could be squeezed from its teats. Since nest no. 2 with its 3 young rabbits was discovered just five days previous (November 29) 30 feet from where this rabbit 10 ♀ was retaken it seems probable that she was the mother of the litter in that nest.

Hamilton's (*op. cit.*) account shows that the behavior of the young of the eastern species differs greatly from that of the Audubon cottontail studied here. Hamilton writes: "I have twice been attracted to a nest by the lusty and repeated squealing of the young while the parents seldom, if ever, visit the young during the daylight the young may be heard squealing at midday." His report is full of such observations which are found not to apply to the Audubon cottontail. The western species differs much in behavior and in details of his life history.

GROWTH

Orr's (*op. cit.*) excellent description of the physical characteristics of this and other species of western rabbits eliminates the necessity of again recording such data here. Certain other data concerning the relative sizes and weights of the two sexes as well as fluctuations in weight at different times, however, supplement his work and are therefore recorded (Table 2). It will be noted that the average female weight (951 grams) is some-what less than the 988 grams recorded by Orr while the average male weight (839 grams) is only slightly less than he reports (841 grams). In either case the difference is not significant since it is well within the variation found to exist between adult individuals or even between the weights of the same individual at different times (See no. 16 ♀ or 17 ♀ Table 2). The females average about 12

TABLE 2.—*Shows the measurements, weights, and variation in the weights of certain individual rabbits during the winter and spring of 1939*

	NUMBER AND SEX	DATES WEIGHED	WEIGHT IN GRAMS	TOTAL LENGTH IN MM.	EAR LENGTH FROM NOTCH IN MM.	HINDFOOT IN MM.	TAIL IN MM.
Mature ♀s	1 ♀	2/ 5/39	913	400	65	85	50
	5 ♀	1/20/39	977				
	11 ♀	1/ 8/39	817				
	16 ♀	1/ 6/39	978	404	70	82	50
		1/30/39	924				
	17 ♀	1/ 7/39	963				
		1/26/39	984	400	68	90	45
		3/26/39	1113				
	27 ♀	9/23/39	891				
Average			951	401	67	85	48
Mature ♂s	4 ♂	1/10/39	892				
	6 ♂	1/17/39	877				
	7 ♂	1/12/39	884	400	69	83	52
		1/28/39	883				
		2/16/39	873				
		4/12/39	820				
	12A ♂	1/16/39	922	405	73	90	45
		2/10/39	966				
		3/ 2/39	927				
	13 ♂	3/ 3/39	842	392	70	89	50
	14 ♂	1/ 7/39	906				
		1/10/39	902				
	19 ♂	2/19/39	700	380	65	78	40
		2/26/39	676				
		3/ 2/39	647				
		3/ 9/39	714				
Average			839	394	69	85	46
Young rabbits	20 ♀ (?)	3/25/39	181*	225	40	55	30
	21 ♂ (?)	3/25/39	154*	210	40	50	29
	22 (?)	3/25/39	95*	172	36	43	24
	23 (?)	3/25/39	100*				
	24 (?)	3/27/39	154**	310	44	48	28
	25 ♂	4/15/39	131	205	36	47	23
		4/22/39	166	210	39	55	25
	26 ♀	5/ 7/39	429	310	57	70	38
	27 ♀	5/29/39	490	325	60	76	35

* These young rabbits presumably are litter mates and were all taken within a few feet of nest no. 4.

** This rabbit may also be from nest no. 4 although taken 2 days later at station A, 40 yards distant.

per cent more in weight than the males. Trippensee (*op. cit.*) and Allen (*op. cit.*) each give an average of 1413 grams for females and 1362 grams and 1398 grams, respectively, for males of *Sylvilagus floridanus mearnsii*. Hence, it is seen that the females are larger than the males in the eastern species also. The heavier weight given by Allen was for male rabbits in winter. Possibly they are heavier then than in the breeding season.

The fluctuation in weight of the same individual over rather short periods of time is considerable. For instance, no. 17 ♀ (Table 2), which was already above average for females, gained 150 grams in less than three months. At about the same period of time no. 7 ♂, which was 45 grams above average weight for males, lost 64 grams and fell to 19 grams below average. This may possibly be correlated with pregnancy and excessive traveling around, respectively, for the female and male during the breeding season. There is great variation in the size of the young rabbits as they leave the nest, no. 20 being almost twice the size of its presumed litter mate no. 22 (Table 2).

There is evidence that females attain full maturity within 6 to 9 months. No. 10 ♀ had milk in her udders in December, six months after she had left nest no. 1. Another (no. 27 ♀) was half grown (Table 2) when first trapped and marked on May 29, 1939. Milk was squeezed from her teats when she was retrapped on September 23, of the same year. Trippensee (*op. cit.*) reports 44 weeks as the time required for *Sylvilagus floridanus mearnsii* to reach sexual maturity in Michigan. Allen (*op. cit.*) found that 3 young juveniles of the eastern species, which were marked in April and June when they weighed 200 grams, had attained full growth by December. With a continuous or nearly continuous breeding season in California it seems that a female could have two or more litters before she is a year old. The relatively small numbers produced per litter when compared with other species of cottontails is thereby compensated.

LIFE SPAN

There are considerable data indicating a relatively short span of life for cottontails. Allen (*op. cit.*) marked 70 individuals of *Sylvilagus floridanus mearnsii* in Michigan in January, February and March. There were 12 of them taken again the next winter. Of 228 animals marked by him only 2 are known to have lived for 2.5 years.

A period of 19 months is the longest time recorded for any one of the 29 rabbits followed during this study (Table 1). Only seven rabbits are known to have lived longer than one year on this area. In the spring months of 1940 three Young traps were kept set continually at station A and regular weekly observations were made to see which rabbits were still found there; only no. 12 A ♂ and the two most recently marked cottontails (no. 27 ♀ and no. 28 ♀) were found to be present.

SUMMARY

1. Twenty-nine ear-marked Audubon cottontails (*Sylvilagus audubonii audubonii*) were studied on a small area in the Sacramento Valley for two and a half years.

2. The rabbits are most active from dusk to dawn in the winter months. In other months the greatest activity is from 3 p.m. to 9 a.m.

3. A preference is indicated for clear days and nights; they are less active in windy rainy weather.

4. Home range for females is about an acre surrounding thick patches of wild blackberries. There may be as many as four females sharing such an area at the same time. The home range of males is perhaps as much as fifteen acres since they are inclined to wander from one thicket to another.

5. Hearing and ability to detect slight movements are the means most used in locating enemies; the sense of smell plays an unimportant part.

6. Freezing, running and dodging are the most effective means of avoiding enemies.

7. The rabbits were relatively free from parasites and diseases known to infect cottontails elsewhere.

8. The food consists of a number of wild herbaceous plants and certain fruits; on this area shrubby plants are never eaten. There is practically no damage inflicted on flower or vegetable gardens.

9. Females are compatible but males are not.

10. The number of young to a litter ranges from one to five with an average of three.

11. The breeding season extends the year around; this probably compensates for the relatively small number of young per litter.

12. The five nests examined were similarly constructed, but the location with respect to cover was variable.

13. A very young rabbit was studied daily until it left the nest ten days later.

14. Considerable fluctuation occurs in the weight of mature rabbits of both sexes from time to time. There is also great variation in the weights of young rabbits when they leave the nest.

15. Nineteen months was the longest record made on a single rabbit during this study, indicating a life span of two years or less.

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THE FOOD OF SMALL FOREST MAMMALS IN EASTERN UNITED STATES

By W. J. HAMILTON, JR.

The small mammals of forested regions in the eastern United States occupy several ecological niches, from well below the humus of the forest floor to the rotted logs and stumps that lie above. Few efforts have been made to study these animals intensively, and other than in a general way, little is known of their specific dietary requirements. This is surprising when one learns how abundant they may be, and their potential significance as an agent for good or harm in the forest. For a number of years I have preserved the stomachs of small mammals as they were trapped and the analyses of these stomachs are now completed. These examinations give a fair picture of the diet of the various common species in the eastern United States.

A recent paper (Hamilton and Cook, 1940) has pointed out the importance of small mammals in destroying insects in the forest, but no emphasis was placed on the specific types of food which they devour.

METHODS

When time permitted, fresh stomachs were examined in the laboratory, although the majority was preserved in 10 per cent formaldehyde until a later date. The advantage of examining fresh stomachs lies in the fact that the collector then has a fresh acquaintance with available food organisms in the

woods and this will enable him, within limits, to reach a decision on certain doubtful items. Many field biologists are under the delusion that stomach analyses of small mammals are quite impossible to make because of the supposed finely comminuted condition of the food. On the contrary, much of the food which is eaten passes into the stomach in an entire condition, or else little damaged, and often its origin may be traced with ease. The seeds of raspberry, shadberry, and blueberry may be recovered intact from the stomachs of deer mice, while shrews often swallow singularly large pieces of food and these are readily determined. Nevertheless, some difficulties are encountered, this being particularly true of the voles, such as *Synaptomys* and *Clethrionomys*. These mice chew their food rather well, and considerable difficulty is experienced in identifying stomach remains from these species.

Direct observation of the feeding habits under natural conditions is seldom possible, because of the secretive and fossorial habits of most species. On rare occasions the investigator may see these small mammals harvesting food, notably the squirrels, but such a method cannot be expected to throw much light on the dietary behavior of most of our small forest mammals.

Examination of the cheek pouches of deer mice, chipmunks and such other forms as possess these structures will often prove profitable. The contents of these pouches are usually in good condition and identification is an easy matter.

In those species that practice storage the stores may often be found and the items readily determined. Even fragmentary remains about the nests and burrows give clues to the food habits.

The food habits of captive specimens are not particularly useful in determining predilections under natural conditions. The necessary close quarters of confinement, minimum activity, and disturbance of feeding rhythm may modify the feeding behavior. I have little faith in the value of feeding experiments on captive animals in determining food predilections. Such procedure should be resorted to only when food habits cannot possibly be determined in any other manner.

In examining stomachs, the contents are first placed into one or more petri dishes and gently teased apart. Several changes of water clean the contents sufficiently to allow recognition of such parts as may be determined. Much of the material is so finely ground that identification is impossible. This is notably true of the starchy paste-like mass found in the stomachs of small rodents, the origin of which is the succulent rootstocks of various plants. Because this material often constitutes a large share of the contents, it is not possible to determine the percentage by bulk. Reference is made, therefore, to the frequency of occurrence of the items in the total number of stomachs examined.

The specimens used in this study have been collected principally by myself in various parts of New York State, particularly about Ithaca in central

western New York State and on the Edmund Niles Huyck Preserve at Rensselaerville, in eastern New York. A number have been taken in Maine, New Hampshire, Vermont, Massachusetts, and Pennsylvania. I am particularly indebted to several of my students who have been good enough to save the carcasses of specimens they have collected from time to time.

HAIRY-TAILED MOLE (*Parascalops breweri*)

This species is the only talpid commonly found in forested regions of the northeastern United States. It is abundant and widespread, often occurring in some numbers. Populations in various habitats run from 1.2 to 12 an acre (Eadie, 1939; Hamilton, 1939).

The food of *Parascalops* has been studied by a few investigators. Brooks (1908) records earthworms, various insects and their larvae but little vegetable matter, and concludes from observations upon a captive mole that the species will eat an amount in excess of its own weight every day. Eadie (1939) examined 100 stomachs of this species, his conclusions being that earthworms, insect larvae and pupae, adult insects, millipedes and centipedes, snails and slugs, and sowbugs constituted the more important food items in the order listed. Among the insects, many injurious families were represented, including the Elateridae, Scarabaeidae, Curculionidae, and Mycetophilidae.

I have examined 29 specimens of this mole all of which have been taken in forested regions, chiefly at Rensselaerville, New York, and about Ithaca. The stomach analyses confirm the observations of Eadie. Earthworms, ants, beetle larvae, centipedes, and small rootlets, the latter probably ingested inadvertently, constituted the primary food of these specimens.

LONG-TAILED SHREWS (*Sorex cinereus* and *Sorex fumeus*)

These diminutive shrews occur in northeastern forests and often constitute a large share of the small mammal population. Their long-pointed snouts and small size permit them to push through the carpet of leaves and loose humus, and their strong hooked incisors act as effective tweezers in obtaining the tiny invertebrates that swarm on the forest floor. Specifically, the food, as determined by stomach analyses, consists chiefly of insects of several orders, a few earthworms, numerous centipedes, millipedes, sowbugs, snails, spiders, some vegetable matter, and the smaller salamanders (Hamilton, 1930). Recent examinations of a large number of stomachs of *Sorex fumeus* confirm the importance of insects and other small invertebrates and emphasize the insignificance of earthworms and mice in their food.

SHORT-TAILED SHREW (*Blarina brevicauda*)

General accounts of the food habits of the short-tailed shrew list insects, worms, slugs, snails, mice and other small vertebrates, and beechnuts as the principal food. According to Merriam (1884), *Blarina* subsists on beechnuts,

earthworms, insects, slugs, sowbugs, and mice. Many beetles and their larvae, moth larvae and other small insects, earthworms and sowbugs, snails of the genus *Polygyra*, and meadow mice are among the chief food items (Shull, 1907). Most investigators who have studied the food habits of *Blarina* agree that this shrew will eat quantities of vegetable matter, including nuts and berries. Babcock (1914) has condensed the writings of others and added observations of his own on the food habits of *Blarina*. The most detailed account of the food habits of this species was based on an examination of 244 stomachs (Hamilton, 1930). This study revealed that insects made up nearly one-half of the food, while next in abundance were vegetable matter, annelids, crustacea, molluscs, vertebrates, centipedes, inorganic matter, arachnids, and millipedes. Only 4 stomachs contained mice.

During the past ten years more than 200 additional stomachs of this species have been examined, making a total of 460. These have been taken in the

TABLE 1.—*Food of the short-tailed shrew throughout the year, based on analyses of 460 stomachs*

FOOD	PER CENT OF OCCURRENCE
Insects	77.6
Annelids	41.8
Vegetable Matter	17.1
Centipedes	7.4
Arachnids	6.1
Mollusca	5.4
Vertebrates	5.2
Crustacea	3.7
Undetermined Matter	2.4

same localities with the *Peromyscus* that have been examined, usually in forested regions of maple, beech and hemlock having a deep ground cover of loose black soil and a substantial leaf mold layer. The results based on frequency of occurrence are listed in table 1.

These additional examinations indicate that earthworms play a more important part in the diet than my earlier analyses had indicated. In situations where worms are abundant, they may be found in fully 50 per cent of the stomachs. Earthworms are bitten in several places but are swallowed in pieces sufficiently large to render identification easy. Almost any species of insects that the shrews happen upon is eaten. They seem to eat adult beetles and the pupal stages of several orders of insects most readily. In addition, many larvae of beetles and Lepidoptera are taken, and numerous crickets, Hemiptera, and other insects have been found in the stomachs. Brooks (1908) remarks on the fondness of this shrew for chestnut worms (*Balininus proboscideus*) and its effectiveness in reducing this pest. Balch

(1936) believes that this shrew is one of the most important enemies of the European spruce sawfly, and that at least half of the cocoons of this insect are destroyed even when the pest is epidemic.

Of the vegetable matter, small nuts (beechnuts and those of similar size) are most favored. Probably seeds are eaten, for shrews take readily to such a diet in captivity. Raspberry seeds and the pulpy parts of various fruits have been found in the stomachs of shrews. In several stomachs the minute black spores of a fungus have been removed. These have been determined by Diehl (1939) as *Endogone* spp. Centipedes are often eaten and the smaller species frequently are almost entire when they reach the stomach. The small cocoons of spiders containing a mass of eggs have been taken from shrew stomachs, in addition to several kinds of spiders.

It has long been known that shrews feed on snails (Shull, 1907; Clench, 1925); they actually move these molluscs from underground chambers to the surface during changes of temperature. Usually the snail is attacked not through the aperture but rather through the apex and spire, which parts are neatly bitten away to expose the animal.

The vertebrates consist principally of salamanders and small mammals, which often abound in the habitat of *Blarina*. It is by no means evident from this study that any considerable quantity of mice are captured, as others have intimated (Kennicott, 1857; Merriam, 1884; Shull, 1907; Seton, 1909). Only 14 stomachs (3 per cent) contained mouse remains and it is probable that some of them represented trap victims. On the other hand, a large *Blarina* had eaten a smoky shrew (*Sorex fumeus*) under circumstances that suggest it had actually killed the smaller animal. I believe the short-tailed shrew has been credited with greater mouse destruction than it is capable of committing.

Isopods are often eaten, their legs and dorsal shields appearing in a number of stomachs that have been examined.

DEER MICE (*Peromyscus leucopus noveboracensis* and *Peromyscus maniculatus gracilis*)

Inasmuch as the two common eastern species of *Peromyscus* often occupy the same habitat and are taken in adjoining traps, and no different food habits are apparent, the two are grouped for convenience. About three times more *leucopus* than *maniculatus* have been examined.

Writers on the food habits of deer mice ascribe a wide assortment of food to these rodents. Seton (1909) states that the deer mouse is essentially a nut-and-seed eater when compared with the grass eating meadow mouse. Stone and Cram (1902) list nuts, berries, and grains and specifically refer to the seeds of pokeweed, rose-hips, red alder berries, and the round seeds of basswood. Nelson (1930) writes that deer mice feed mainly on many kinds of seeds and nuts and vary this diet with snails, insects, and sometimes with the flesh of dead birds and mice. Osgood (1909) remarks that very few feed

extensively upon green and succulent food but prefer dry food, especially seeds and small nuts. He states that *noveboracensis* is especially fond of basswood seeds, pits of wild cherries, beechnuts, and acorns. Kennicott (1857) records a stump in a clover field in western New York that contained several quarts of clean seed of red clover collected by a family of *Peromyscus*. Deer mice are so fond of seeds that they may constitute a serious problem to the forester in his attempts at reforesting (Dearborn, 1911). Seventy per cent of the seeds in a half acre planting were pilfered by chipmunks and deer mice. Cogshall (1928) has given a long list of seeds, fruits, nuts, buds and bark, insects, and other animals eaten by four species of captive *Peromyscus*. From this study it was presumed that food is probably not an important factor in limiting the habitat distribution of the different species of deer mice.

Erickson (1938) believes insects form one of the staple diets of Minnesota deer mice. Particles of chitin, intact insect legs and antennae, as well as the remains of spiders were found in the digestive tract of these mice. In addition, the digestive tract of nearly every deer mouse contained grit, and it was presumed that the rodents had eaten it to satisfy a need for minerals. Graham (1929), on the basis of observations in Michigan, concluded that mice, presumably *Peromyscus*, open and destroy on the average about 60 per cent of the sawfly larvae that succeed in spinning cocoons. Everman and Clark (1920) report deer mice feeding on small snails and other delicate molluscs. The storehouses of two mouse nests found in oak woods near Ann Arbor, Michigan, apparently belonging to *Peromyscus leucopus noveboracensis*, according to Blanchard (1935) contained about a pint of tubers, rhizomes and seeds that were identified as pepper root, *Dentaria laciniata*, the root stocks of *Viola soraria* and the large underground pods of the hog peanut, *Amphicarpa monoica*, tubers of spring beauty, *Claytonia virginica*, and large rhizomes of *Geranium maculatum*. To the writer, these stores appear more likely the work of the pine mouse.

Late fall and winter food habits.—Examination of 180 deer mouse stomachs collected from November to April indicate that the food habits do not differ markedly from those of the spring and summer. Insects, mast, seeds, and green vegetation (presumably small buds) constitute the largest share of the food. It is not surprising that insects should be eaten so regularly during the winter, for at this season they are sluggish and occur in considerable numbers in the burrows and crevices of stumps and logs which the mice frequent.

Among the insects, carabid beetles, centipedes and spiders (these are included under insects for convenience), weevils, adult flies, pupal cases of small species, tipulid larvae, and undetermined fragments of beetles constitute the more important items. During March several stomachs contained remains of small stoneflies (*Allocapnia*), which crawl over the snow after transforming.

The starchy matter that often occupies the entire stomach of wild mice

during the winter is composed largely of the meat of small nuts and seeds. To determine this, several mice were fed on walnut meat, acorns, hickory, basswood seeds, cherry seeds, and beechnuts, then killed. The stomach contents consisted of the white starchy mass, with fragments of the brown coats that covers the nuts. The mass is often pale blue in color but to what this coloration is due could not be determined. Much of the food at this time is obtained from the large stores laboriously cached during the summer and fall months. In August in northern Maine I have trapped *Peromyscus* that had their cheek pouches well filled with the tiny seeds of blueberry. Their stores often contain a sizeable cache of food. I once found nearly a peck of beechnuts, many of which had been husked, in a cavity 40 feet from the ground in a beech tree, which had apparently been gathered by the two mice that were living in the cavity with the cache. Basswood seeds are gathered and placed in basal cavities of trees or concealed in a woodpecker's hole that had been utilized by deer mice. The seeds of wild cherry are often carried to deserted birds' nests where they are opened and the contents eaten.

TABLE 2.—*Late fall and winter food of Peromyscus (Nov.–April) based on stomach analyses of 180 specimens*

FOOD	PER CENT OF OCCURRENCE
Insects	72.8
Starchy matter, presumably mast, seeds, etc.	43.9
Green vegetation	20.5
Mammal remains	4.4
Molluscs	3.9
Birds	1.7
Annelids	1.7

The green vegetation constitutes, I believe, the small buds and sprouting shoots that lie below the dead leaves on the forest floor. I have had captive mice eat the new leaves of the barren strawberry, *Waldsteinia*, and it is probable they eat a number of other green succulents in early spring, as they certainly do in captivity (Cogshall, 1928).

The stomachs of several mice, secured in January and February, contained remains of their own kind, the flesh and fur leaving no doubt as to the identity. It is impossible to say whether the victims were killed by their own kind or were found dead. Captive mice eat flesh avidly and they will occasionally kill and partially eat their comrades when caged together. Often the stomachs contain small balls of fur, particularly near the pylorus. I suspect that these hairs have been inadvertently ingested while the mice have been cleaning themselves or attempting to remove parasites.

Small snails, principally *Polygyra*, are often eaten by deer mice. The shell is eaten, for the smaller species have a delicate armature that is readily broken by the teeth of deer mice.

It is quite probable that the bird remains found in the stomachs of deer mice represent carrion, but it is not impossible that the mice are able to capture small birds as they sleep. Juncos, and perhaps other species, have been recorded sleeping under clumps of yew on the forest floor, where these small mice abound (Hamilton, 1940).

A few stomachs contain large numbers of small enchytrid annelids, which are often abundant in the damp leaves and rotten logs of the forest. One mouse had eaten a small earthworm.

Spring and summer food.—As winter wanes and frost leaves the ground, many small invertebrates become active; plants flower and produce fruits and food becomes more varied and abundant for the small forest mammals.

Insects, while actually represented in a slightly smaller per cent of the stomachs than in the fall and winter specimens, are numerically greater. From early summer to September some mice were collected that had fed largely upon insects, chief among which are small grubs and lepidopterous

TABLE 3.—*Spring and summer food of Peromyscus (May–October) based on stomach analyses of 346 specimens*

FOOD	PER CENT OF OCCURRENCE
Insects	71.4
Fruit	52.3
Starchy matter, presumably mast, seeds, etc.	20.8
Mammals	4.3
Fungi	3.7
Birds	2.3
Crustacea	2.0
Molluscs	1.2

caterpillars, the larvae of sawflies, adult diptera (which mice are said to catch in their mouth or with their forepaws), crickets, and other small fry that infest the burrows of these mammals. Centipedes (again grouped with insects for convenience) are eaten in considerable quantities, particularly *Lithobius forficatus* and *Cryptops hyalinus*. Small herbivorous maggots, grasshoppers, an occasional ant, thrips, numerous beetles of several families, and miscellaneous insects, the fragmentary remains of which were too minute to identify, have been found in the stomachs of mice. R. H. Gensch of the Food Habits Division, Fish and Wildlife Service, lists the following insects from the stomachs of *Peromyscus leucopus noveboracensis* that I collected in eastern New York: *Heterocerca* sp., Pentatomidae nymphs, Sarcophagidae larvae, Chrysomelidae larvae, Coccinellidae larvae, Eurytomidae fragments and numerous lepidopterous larvae.

Fruit constitutes the bulk of the food during the summer months. When blueberries, raspberries, and blackberries are available, they are a most impor-

tant food. The stomach and viscera actually may be stained from this continued fare. Examination of the stomachs reveal numerous seeds, some as large as blackberry, these having been swallowed whole. Mice will travel some distance to reach an isolated patch of blackberries. Burt (1940) has shown that the home range of the deer mouse in southern Michigan ranges from a quarter to half an acre. Several deer mice (*Peromyscus leucopus noveboracensis*) that I marked at Rensselaerville, New York, during the summer of 1937 had similarly restricted home ranges, but actually travelled 400 feet from the outermost limits of their normal range to feast on the blackberries and carry off the seeds for storage. This was demonstrated by live trapping.

The different fruits and seeds listed below have been taken either from the cheek pouches, stomach, or food caches of *Peromyscus leucopus noveboracensis* and *Peromyscus maniculatus gracilis*.

Taxus canadensis. Ground Hemlock.
Tsuga canadensis. Hemlock.
Clintonia borealis. Clintonia.
Smilacina racemosa. False Spikenhard.
Maianthemum canadense. False Lily-of-the-Valley.
Medeola virginiana. Indian Cucumber.
Polygonum scandens. Climbing False Buckwheat.
Carya orata. Shagbark Hickory.
Corylus americana. Hazelnut.
Ostrya virginiana. Hop Hornbeam.
Fagus grandifolia. Beech.
Phytolacca americana. Pokeweed.
Trollius laxus. Globe Flower.
Actaea rubra. Red Baneberry.
Liriodendron tulipfera. Tulip Tree.
Caulophyllum thalictroides. Blue Cohosh.
Tiarella cordifolia. False Mitrewort.
Ribes americana. Wild Black Currant.
Aronia sp. Chokecherry.
Amelanchier sp. Shadbush.
Fragaria virginiana. Field strawberry.
Rubus sp. Wild Blackberry and Raspberry.
Rosa sp. Wild Rose.
Prunus pennsylvanica. Pin Cherry.
Prunus virginiana. Choke Cherry.
Prunus serotina. Wild Black Cherry.
Medicago satira. Alfalfa.
Desmodium canadense. Tick Trefoil.
Ilex verticillata. Black Alder.
Impatiens sp. Jewelweed.
Tilia americana. Basswood.
Cornus amomum. Silky Dogwood.
Cornus candidissima. Gray Dogwood.
Gaultheria procumbens. Checkerberry.
Vaccinium uliginosum. Bilberry.
Vaccinium canadense. Blueberry.
Fraxinus americana. White Ash.
Solanum dulcamara. Blue Nightshade.
Mitchella repens. Partridge Berry.
Viburnum acerifolium. Maple-leaved Viburnum.
Viburnum dentatum. Arrow-wood.
Sambucus racemosa. Red-berried Elder.

Mast is eaten extensively in October, and much is stored. Beechnuts, acorns, and ripening seeds of all sorts are stored for winter use.

There is some evidence that deer mice eat their own kind, and remains of young undetermined mammals in the stomach contents of several mice have been found in July and August. It is possible that the parent may eat her own young on occasion, or that wandering males may victimize the nests of their own kind.

Fungi is eaten by several species of small mammals, but the identity of such, other than *Endogone*, eaten by deer mice is not known.

Fragmentary remains of sowbugs and small snails are occasionally found in summer-caught deer mice.

RED-BACKED MOUSE (*Clethrionomys gapperi gapperi*)

Little study has been given by naturalists to the food of this forest mouse. The best account is by Rhoads (1903):

> "He lives on the leaves and tender stems of many weeds and grasses and also enjoys the nuts and seeds of several species of trees, especially beechnuts, chestnuts, hazelnuts and acorns, for which it frequently makes excursions into the dry upland forests and hill tops. It also seems to be fond of certain shelled snails, as *Omphalina* and small *Polygyra*, these being found in the retreats where the mice are trapped. They secure the snail by gnawing a hole into the apex of the shell and drawing the body out backward. In winter I have found that they live almost entirely on the leaves of the evergreen strawberry bush, *Euonymus americanus*, which grows abundantly in the cedar swamps and damp hemlock forests . . . . It often runs about and searches food in the open daylight, climbing up the stems of Euonymus to cut off a supply of leaves."

Merriam (1884) records the red-backed mouse as feeding upon beechnuts and a variety of seeds, berries, and roots, and also at certain times in the winter, upon the bark of beech, maple, ash, and basswood.

Stomach analyses of red-backed mice are not as satisfactory as of deer mice. The food is chewed finer, and the greater amount of green matter is often so well triturated that it is impossible to determine the original source. Of a considerable number of stomachs saved from 1933 to 1939, 100 have been selected for study. These represent March to December specimens, the greater number having been secured in April, May, July, and October.

Nearly three-fourths of the food is composed of green vegetation usually too finely ground for identification. In addition to this, the starchy paste-like mass of nuts and seeds often occupies the larger share of the stomach. Seeds of *Rubus*, *Amelanchier*, and *Vaccinium* have been found in the stomachs. These mice do not eat insects so frequently as do the deer mice, slightly more than 10 per cent of the stomachs containing insect remains. Of those eaten, remains of ground beetles, adult flies, and lepidopterous larvae have been recognized. In addition, centipedes and spiders are consumed. A single stomach contained the remains of a snail.

While setting traps in yellow birch woods in the Catskill Mountains, near Westkill, New York on July 26, 1940, I noticed numerous small tooth marks on the broad heads of mushrooms, *Lactarius ligniotus*. Several traps were placed on these fungi. The following morning one of the traps held a red-backed mouse, and several additional specimens were captured nearby. It appears probable that these mice were responsible for the tooth-marked fungi.

Red-backed mice make no pretense at hibernation; nevertheless they are active in the autumn gathering stores for the coming winter. Walter Crissey saw a dozen of them in less than an hour, scampering over the fallen leaves in

search of food early in November, 1937, near Inlet, New York. One mouse had a beechnut in each cheek and another held in its jaws. I observed three mice ostensibly in search of food late in November, 1937, near Ithaca, New York. They hunted industriously for several minutes at a time, retired to their various tunnels for a few minutes, reappeared shortly, and again resumed their food quest. The leaves of checkerberry (*Gaultheria procumbens*) were bitten off and discarded while a small section of the petiole was carried to the underground chambers.

LEMMING MOUSE (*Synaptomys cooperi*)

Lemming mice are locally common in the eastern United States, occurring in bogs, fields, and more particularly damp woods with an adequate leaf-mold cover. Their food has been little studied. Burt (1928) records stomachs of *Synaptomys cooperi gossi* well filled with blue grass, *Poa pratensis*, the mycelial threads and spores of a fungus (*Endogone* sp.), and fragments of a halipid beetle. Sedge (Cyperacea) leaves are recorded from the stomachs of lemming mice (Howell, 1927).

The dozen stomachs that I have examined have all been from mice taken in forested regions. Even here, as with the bog and meadow individuals, the stomach contents consist of finely chewed green vegetation that makes identification difficult. From the burrows occupied by these mice I have recovered the small cut twigs and partially eaten leaves of seedling beech. The remains of *Polygyra* shells have likewise been removed from such burrows, but they may have been the work of other small mammals frequenting the tunnels occupied by *Synaptomys*.

The stomachs of 7 or the 12 specimens contained the small truffle-like fructifications or zygospores and abundant hyphal network of the hypogeous fungi, *Endogone*. These were determined by Diehl (1939) as *E. macrospora*. In addition to *Synaptomys*, I have found these *Endogone* zygospores in *Sorex fumeus* and *S. cinereus*, *Blarina*, *Peromyscus* and *Clethrionomys*. All of these species occupy, at some time, the stratum where this fungus grows, and it appears to be a food of more than passing importance to the several species.

Three stomachs contained fragmentary remains of insects, chiefly well digested larvae and fragments of beetles.

WOODLAND JUMPING MOUSE (*Napaeozapus insignis insignis*)

This handsome species occurs in the forested regions of eastern United States, often in considerable numbers. It may upon occasion actually outnumber the deer mouse.

The food habits have been casually studied by several investigators. Saunders (1921) notes its fondness for alder cones. Sheldon (1938) records various insects and berries eaten by captive specimens. A number of stomach analyses of *Napaeozapus*, reported in an earlier paper (Hamilton, 1935)

showed that insect larvae, enchytrid worms, various beetles, and adult flies were eaten. In addition, the seeds of mitrewort (*Mitella diphylla*) and the green fruit of Mayapple (*Podophyllum peltatum*) were eaten.

Forty additional stomachs have been analyzed since my last report. The results suggest that insect larvae, particularly lepidopterous and dipterous forms, are taken in considerable quantities. In addition, spiders, small soil worms, centipedes, and various small invertebrates are consumed. Blueberries, raspberries, quantities of small seeds and tiny nuts, and small green leaves are eaten. Fragments of *Asplenium* fronds have been recognized in stomachs of these mice.

While *Napaeozapus* is a confirmed hibernator and probably does not make stores of food, captive individuals do practice a limited storage. No caches have been found near the dormant mice under natural conditions.

DISCUSSION

The ecologic and economic significance of our small forest mammals has long been overlooked by field biologists. Their great numbers, the habitat they select, their adaptibility, and their widespread occurrence make them not only of great scientific interest but of considerable potential importance. On the one hand, the girdling activities of a few forest species, the pilfering of seeds from forest nurseries, and other incidental damage may be credited against these small mammals. On the other hand, mice and shrews destroy numerous insects, loosen the soil and by the accumulation and subsequent decay of buried stores, nests, feces, and their own bodies, they tend to enrich and make more porous and friable the zone of occupancy, perhaps aiding in no small measure to plant growth. Moreover, they supply a number of predatory mammals with food, and in this manner act as a buffer agency.

The amount of food eaten by these small mammals is considerable. We can determine this by weighing the contents of a series of full stomachs for the various species. It is known that the stomach is filled at least twice every 24 hours (a conservative estimate based on the feeding habits of captive species). From this may be judged the total amount eaten by a mixed population of small mammals in a forested region. Under natural conditions, adult deer mice eat about 30 per cent of their weight daily, or 6 grams of food; jumping mice and red-back mice a similar amount, lemming mice considerably more than this, short-tailed shrews about half their weight or 9 grams, and the long-tailed shrews from 2 to 4 grams of food daily. If we have a mixed population numbering from 60 to 100 mammals an acre (not excessive in northeastern forested regions), we thus find that the small mammal population is consuming from .85 to 1.2 pounds of food daily. In addition to the food actually eaten, much is stored, a proportion of which is never eaten.

It is conceivable that when mice are abundant, they may efficiently garner so much food, particularly beechnuts and acorns, that a scarcity of these items

will result, thus reducing the food of grouse, deer, and other larger animals. Conversely, the large proportion of insects that constitute their diet suggests that they may have a decided levelling affect on them, and so materially reduce the insect population of the forest. The food habits of these small animals offers opportunity for speculation; it is probable that this phase of their life is one of utmost significance in the ecology of forested regions.

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Cornell University, Ithaca, New York.

NOTES ON SHREWS OF THE GENUS NOTIOSOREX

BY HARVEY I. FISHER

On the night of June 2, 1940, a male shrew of the genus *Notiosorex* was trapped 5 miles east and 1 mile north of Grapevine Peak, Nye County, Nevada, at an elevation of 5500 feet. This specimen (no. 92391 Mus. Vert. Zool.) exhibits differences from *Notiosorex crawfordi* of southern California that cannot be attributed to seasonal, sexual, age, or individual variation. The possibility of its being a juvenile is precluded by the fact that it had well developed testes and inguinal blood vessels; also, the measurements fall within the range of those for adult males of *crawfordi* and the teeth are well worn. Comparisons have been made with other *Notiosorex* showing the same degree of wear on the teeth and taken at the same time of the year.

Measurements of the specimen are: Total length, 89 mm.; tail vertebrae, 26; hind foot, 10; ear from notch, 8; skull length, 16.7; palatal length, 6.8; cranial breadth, 8.1; interorbital breadth, 3.9; maxillary breadth, 4.8; tooth row from front of second incisor, 6.2.

The peculiarities of the Nevadan specimen are essentially of the same magnitude as those used to divide other shrews into subspecific and perhaps even specific categories. I present here its morphological features in the hope they may be of use to other workers should the collection of more specimens make feasible the naming of a new form.

The dorsal surface is a light, silvery gray color, partly washed with brown, instead of the usual dull, plumbeous gray covered with brown. One might say that the animal is semi-agouti. Examination of individual hairs under the microscope shows the basal two-thirds to be lead gray in shrews of this

genus, but in the specimen from Nye County the gray is somewhat lighter. The silvery gray band distal to the lead gray is wider in the Nevadan specimen and sometimes extends to the tip. Short tips of light brown on some hairs produce the brownish wash. In the Californian *Notiosorex* a brown band one-third to one-half the width of the light gray band is present on all the tips.

The specimen from Nevada is much lighter ventrally and has little of the brown found in the other 7 *Notiosorex* examined. The tail is more heavily furred and has longer, more silvery hairs compared with the fewer, shorter, more brownish hairs on the tails of the others.

Comparable males in California have longer skulls with slightly greater palatal lengths and shorter interorbital measurements. The impression

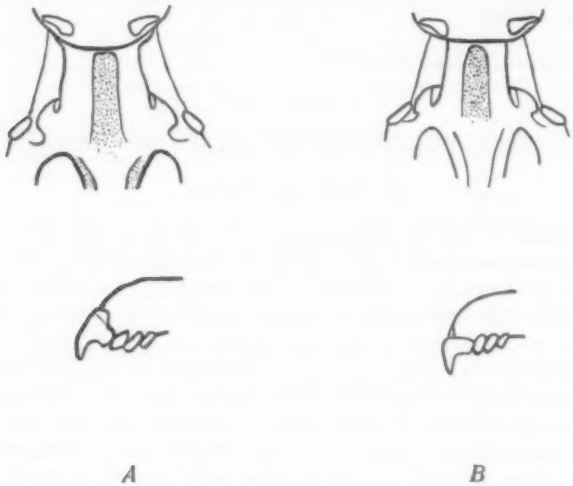

FIG. 1. Pterygoid region and rostrum of *Notiosorex*. A. M.V.Z. no. 7474, Vallecito, San Diego County, California. B. M.V.Z. no. 92391, Nye County, Nevada.

received is that this Nevadan shrew has a more compact skull with a more arched cranium. The greatest skull difference as compared with other specimens is the narrower and lighter pterygoid bones. The width from outside to outside of the pterygoid bones at their anterior ends is about 15 per cent less whereas the posterior width is approximately the same. Thus the pterygoids form a more acute angle anteriorly. In lateral view the anterior edge of the rostrum turns ventrad more abruptly (see fig. 1 A–B).

Incisors 1 in both jaws are shorter. Part of this may perhaps be attributed to wear, but other males showing more wear on the molars have upper and lower incisors 15 to 20 per cent longer. Not only are these incisors longer, but they are set on the edge of the premaxillary in line with the unicuspid

teeth in the maxillary and do not project forward. In the California specimens the incisors take root higher in the premaxillary, protrude forward and exclude the premaxillary from the anterior tip of the rostrum (see fig. 1).

To me these variations seem to indicate that we are dealing with two different kinds of shrews, but the differences do not justify the naming of a new form with only one specimen at hand.

In the absence of any compilation of the records of *Notiosorex* since Merriam's revision (1895), it is perhaps worthwhile to note the localities at which shrews of this type have been taken and to review, as far as possible, habitat

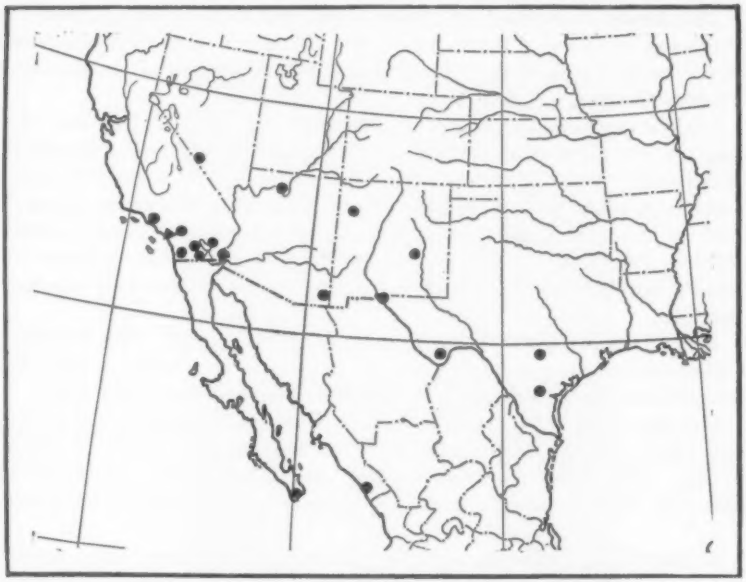

FIG. 2. Localities whence *Notiosorex* has been taken

conditions. In addition, facts concerning the animal associates, food, and parasites of the Nevada specimen may be mentioned.

Previous records of *Notiosorex* are few. I have found none for the state of Nevada. Specimens have now been taken at the following localities:

Texas: El Paso, El Paso County, type, 1; Big Bend, Brewster County, 1; San Diego, Duval County, 4; San Antonio, Bexar County, 1. **New Mexico:** northwest base of Capitan Mountains, Lincoln County, 1; Juan Tofoya, Valencia County, 1. **Arizona:** Bright Angel Trail, Grand Canyon National Park, Coconino County, 1; Pinery Canyon, Chiricahua Mountains, Cochise County, 1. **Nevada** (new record): 5 mi. E, 1 mi. N Grapevine Peak, Nye County, 1. **California:** Timber Canyon, Santa Paula, Ventura

County, 1; Rancho La Brea, Los Angeles County, skull, skull fragments, and numerous jaws from the Pleistocene; Reche Canyon, Colton, 1, San Bernardino, 2, Dos Palmos Spring, 1, San Bernardino County; Palo Verde, Imperial County, 1; Santa Ysabel, 1, Vallecito, 1, Bernardo, 1, 9 mi. S Escondido, 1, 4 mi. S Escondido, 1, San Diego, 1, San Diego County. **Lower California**: Santa Anita, Cape region, 2. **Sinaloa**: Mazatlan, 1.

The larger number of specimens from southern California does not necessarily indicate a greater number of these shrews in that region. Probably more collectors have worked the area. Five shrews were captured in apiaries there. From the small number of widely scattered records of occurrence it is not possible to plot a definite range for *Notiosorex crawfordi* (fig. 2).

This survey of records nevertheless shows that the Nevada specimen constitutes an extension of known range some 275 miles west and 100 miles north of the locality in the Grand Canyon and 200 miles north of the locality in Ventura County, California.

Little is known of the natural habitat of *N. crawfordi*. It has been taken near sea level, and at an altitude of 6500 feet in the Chiricahua Mountains of Arizona. Of the 27 Recent specimens listed, five were taken from empty beehives in which the bees had recently died, but these shrews can hardly be said to have been living under completely natural conditions. Grinnell (MS) in 1908 caught a female, apparently nursing, on "desert gravel" at Dos Palmos Spring, California, near Carrizo Creek, which had only seepage at the time.

W. P. Taylor took a male on "typical desert soil" in July, 1908, at Colton, California, but his notes describing the immediate area mention *Hyla*, *Reithrodontomys*, Anna hummingbirds, meadowlarks and cultivated fields.

In a trap set for harvest mice in the tules of an alkaline marsh near Vallecito, San Diego County, California, Frank Stephens captured a male *Notiosorex* in May, 1909. His field notes regarding the catch state that "the bordering hills were clay, cemented gravel . . . with blown sand in patches everywhere . . . ."

At Palo Verde, California, in the tules of the Colorado River bottom another shrew was trapped. Charles Schnack of Escondido, California, found one under a pile of cut cornstalks on a hillside. Vernon Bailey (1931, p. 369) collected a shrew under the canvas floor of his tent as he was moving a camp in New Mexico. At the foot of a cliff at the east base of Burro Mesa in Brewster County, Texas, only 50 yards from a water seep a *Notiosorex* was trapped by Borell (MS).

Oldfield Thomas (1888) states that William Taylor of San Diego, Texas, who sent three specimens to the British Museum found that the shrew "lives rather an exposed life and is generally found in heaps of rubbish and old piles of firewood."

Some idea of the habitat and the animal associates of the Nevada-taken shrew may be gathered from a description of the region and from trapping

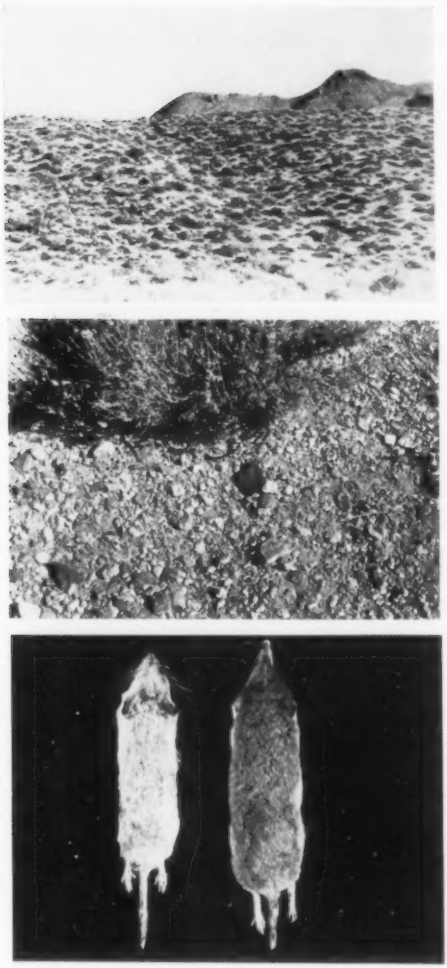

PLATE 1

UPPER: Habitat of *Notiosorex*, 5 miles east and 1 mile north of Grapevine Peak, Nye County, Nevada, 5500 feet.

MIDDLE: Soil type at the trap site.

LOWER: A. *Notiosorex* from Nye County, Nevada (M.V.Z. no. 92391). B. *Notiosorex* from Vallecito, San Diego County, California (M.V.Z. no. 7474).

records. Where the eastern slope of the Grapevine Mountains meets Sarcobatus Flats, the soil is of a loose, sandy texture and is covered by small rocks and pebbles. Only in the dry stream bottoms of the washes where a fine mixture of sand, clay, and pebbles predominates is the ground surface free of shrubbery. Over the rest of the area the shrubs are about 18 to 24 inches high and spaced at 2 to 3 foot intervals. A few Joshua trees are scattered about on the benches (plate 1, top).

Plants collected within 50 yards of the *Notiosorex* trap site included *Artemisia tridentata*, *Ephedra viridis*, *Peucephyllum schottii*, *Chrysothamnus viscidiflorus*, *Eriogonum fasciculatum*, *Atriplex*, *Erigeron concinnus*, *Viguiera multiflora*, *Stipa*, and *Hugelia eremica*. The first four named were by far the most abundant. Only a few bunches of *Stipa* and *Hugelia* were found.

The shrew was caught on the south-facing slope of a wash 60 feet from the bottom. The angle of the slope was about 45 degrees. Small pebbles covered the sandy soil, and several boulders 1 to 2 feet in diameter were within a 10-foot radius. Fifteen yards west of the trap site an area about 50 feet square was covered with conglomerate rocks several feet in diameter. Plate 1, middle, shows the soil at the exact trap location under a *Chrysothamnus* bush. No surface water was seen near by. A spring 2½ miles east and ½ mile south of Grapevine Peak was the nearest possible, observed source.

One hundred mouse traps had been set at 10-pace intervals on the night the shrew was taken (75 in the washes and 25 on the benches). The catch included other mammals as follows: 11 *Peromyscus maniculatus*, 2 *Peromyscus crinitus*, 1 *Dipodomys microps*, 1 *Neotoma lepida*, 10 *Perognathus formosus*. Eight days later, on June 10, I set 70 mouse traps irregularly in an area 50 yards in diameter, using the shrew set as the center of the circle. The catch was 1 *Neotoma lepida*, 2 *Perognathus formosus* and 1 *Peromyscus maniculatus*. The wood rat was caught in a rock outcropping 75 yards south of the *Notiosorex* trap site.

That *Notiosorex* can live under arid desert conditions has been demonstrated by the Recent records as well as by the numerous fragments found in the apparently somewhat arid Pleistocene of Rancho La Brea. But this shrew is by no means limited in its distribution to such conditions.

Old beehives, piles of rubbish and firewood, and shocks of corn are known to contain many insect larvae. Likewise, in the dry desert, hymenopterans are frequently found in abundance, especially around piles of rocks. Perhaps *Notiosorex* feeds largely on insect larvae. That it may take other invertebrates is shown by the stomach contents of the new specimen. The stomach was full of soft insect exoskeletal material and insect appendages too small and incomplete for identification. It was possible, however, to distinguish five non-insect appendages as belonging to some centipede. Numerous short hairs in the stomach were found to be insectivore hairs, probably of this shrew.

From the small intestine were obtained several scolices and proglottids of

the cestode worm, *Raillietina* sp. A single spiruroid nematode, possibly *Spirura*, was found in the stomach. Spiruroid worms are frequently encountered in mammals feeding on insects since the latter serve as intermediate hosts for a number of species.

I am indebted to Dr. Harold Kirby, Jr., for the identification of the parasites and to the Herbarium of the University of California at Berkeley for the determination of the plant species.

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Museum of Vertebrate Zoology, University of California, Berkeley, California.

GROUND SQUIRREL STUDIES IN THE FOUR-RIVERS COUNTRY, WASHINGTON

By Theo. H. Scheffer

In their history and environment the ground squirrel of the lower Columbia river country in eastern Washington, from the mouth of the Yakima to the Wallula water gap, have an interest that attaches particularly to this region. Here, in a wide sweep of the Columbia River as it turns westward toward the sea, it receives two of its larger inland tributaries—the Snake from the more northern Rockies and the mountains of southern Idaho, and the Yakima from the eastern slopes of the Cascades. A few miles farther down stream the Walla Walla River also enters the Columbia, just above the picturesque water gap where the latter finds a way to the coast.

The elevation of the confluent valleys is less than 300 feet; the life zone is Upper Sonoran. The natural covering of the land, rather scant in some places, is largely sagebrush and bunchgrass on the flats, with bunchgrass dominating on the Horse Heaven hills to the south of Kennewick. In this dominant plant society we find a scattering representation of native plants that will be considered in connection with the squirrels' food habits. Incidentally, too, the ditch and the plow have brought in several cultivated plants and nuisance species, with their reflex bearing on the native fauna.

Spring comes early in this Four-rivers country but, in consequence, bud and blossom are sometimes nipped by a return of regional frosts. Under and about the sheltering sage, grass starts in late January. Though short, it suffices for the nibbling of the first squirrels that come out of hibernation to whet their seasonal desires with green foods. May we anticipate their brief day in the sun by saying that in less than five months, perhaps no more than four in the case of these first comers, they will have bulging waist lines and a plethoric urge to curl up and sleep the summer, autumn, and winter hours away.

Shortly after the appearance of the first squirrels, commonly males, in late January and early February, the females follow and the stage is set for polygamous mating. There is then much reckless scurrying about in the smaller open flats of the sagebrush, with attendant peril from hereditary predators. This is but another danger crisis in their lives; for during their prolonged sleep they have been thinned out in numbers by the persistent badger, who follows his nose and his raking claws to their hibernating chambers. Escaping these perils, they mate so successfully that I have never, in several seasons' investigations, taken a virgin female. Details and summaries concerning the birth and development of the young will be found in the tabulations and field notes introduced herewith.

The two species of ground squirrels considered in these studies are distinct in themselves, though separated here only by the barrier of the Columbia

River. There is little difference in outward appearance of the two species, except that the one on the east side of the Columbia is distinctly spotted, while the one on the west side has no maculate pelage markings. The accumulated data for the reproductive period in these two squirrels, the subsequent development of the young, and the activities of both young and adults in the brief span until they aestivate in late May and in June, will be presented here as of interrupted periods of close field contacts.

February 15–16, 1924.—On this the first field contact of the investigations west of the Columbia River, the Townsend ground squirrels (*Citellus townsendii townsendii*) were found to be already active, both males and females being abroad in the small sagebrush flats about Kennewick, Washington. Local observers reported them out the last week in January. Green food was plentiful and the stomachs examined were gorged with it. The males showed no excess fat remaining from their hibernation but the females still had a small surplus. The species was already breeding. Five specimens taken on the afternoon of February 16 provided the following data:

Males, 2; probably yearlings, the testes measuring 7½ by 15 mm. Female, pregnancy indicated but not established. Female, early stage of pregnancy; 9 fetal sacs 4 mm. in diameter. Female, early stage of pregnancy; 9 fetal sacs 9 mm. in diameter.

March 14–18, 1924.—Investigations in the same squirrel colonies, near Kennewick, disclosed that the mating season was already over and that nearly all of the females were suckling young. Sexual organs in the males were already much reduced in size. Breeding condition of squirrels taken showed:

Males, 4; testes 3 by 7 mm. (normal size in breeding season about 9 x 16 mm.). Females, 3, showing fetal scars respectively 8, 8, and 9 in number. Females, 5, whose appearance indicated that they were suckling young. Female, 1, in advanced stage of pregnancy; 8 fetal sacs 16 x 31 mm.

April 21–27, 1924.—At this time the young squirrels were out in great numbers and approximately half grown, as indicated by average weight as compared with adults. Occasional family groups of from 4 to 7 squirrels might be seen sitting erect near a single burrow entrance, but for the most part the young squirrels were scattered about the many retreats of the colony, one or two at a place. The adult males of the species had already taken on considerable excess fat, the females a lesser amount, due undoubtedly to the recent stress of suckling their young. Weights of twenty young squirrels taken at this time averaged: males, 111 grams; females, 102 grams. The sexual organs in these young squirrels were, in the course of their development, no more inconspicuous than the corresponding parts of the adults. The horns of the uterus in the females were about 1 mm in diameter; the testes of the males were approximately 2 x 4 mm.

June 2–7, 1924.—Inspection of numerous squirrel colonies of the Townsend

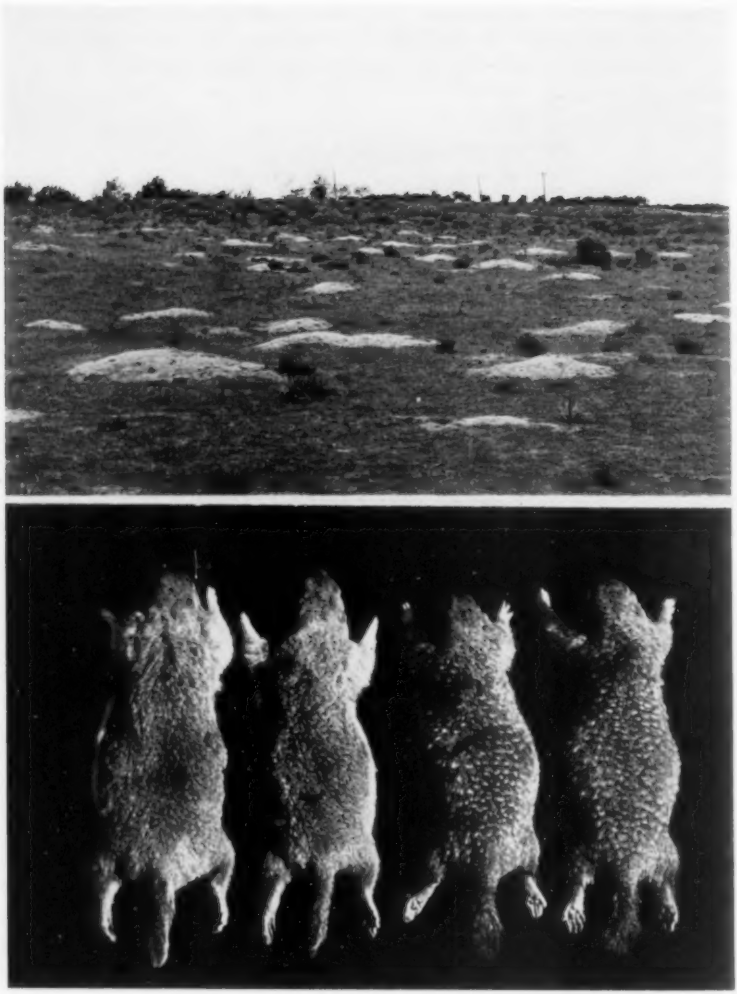

PLATE 1

UPPER: Showing old badger diggings, common in squirrel colonies at Kennewick, Washington. Photographed April 25, 1925 (Biol. Surv. no. 27881).

LOWER: Specimens of *Citellus townsendii*, left (♂ outside, ♀ inside) and *Citellus washingtoni*, right (♂ outside, ♀ inside).

species, on the Kennewick flats and in the Horse Heaven hills a few miles to the south, showed that these little animals were not nearly so active as at the time of the late April investigations. They were shy now, their calls were seldom heard and they did not usually take the trouble to sit erect to watch the approach of an observer. In physical appearance they had broadened out considerably in a few weeks, until they were shaped much like miniature badgers. In the hotter part of the day they were seldom seen abroad, but in the mornings and evenings one would encounter them stealthily foraging. As only a few of the squirrels taken in the traps and few, if any, of those viewed with the field glasses appeared to be adults, it is evident that the older animals had largely holed up for the season. The average weight of 6 young females taken at this time was 184 grams; of 6 young males, 222 grams. Fresh badger diggings in four or five situations in the colonies indicated that the fat, aestivating squirrels were already on the predatory animal's bill of fare.

June 23–27, 1924.—The squirrel colony sites in the Kennewick country were practically deserted; paths from burrow to burrow and to feeding grounds showed disuse; vegetation was dead and dry, except on the irrigated lands. No squirrel note or call was heard in two days' investigations. On rounds of the colonies several times each day the observer was able to locate only 7 squirrels, each at a burrow entrance in the morning hours. Three of these were observed a second time. One squirrel was taken along a canal bank adjacent to an alfalfa field. This animal had its stomach full of green food.

August 21, 1924.—Fresh badger diggings were noted in the deserted colony sites of the Townsend ground squirrel, in the Kennewick country. The excavated soil of such diggings, fresh or weathered, marks conspicuously many of the small, open flats as squirrel towns.

February 3–7, 1925.—On this first return of the season to the squirrel colonies of the Kennewick country, about ten days earlier than in the previous year, we found the Townsend species out of hibernation. According to a number of reliable reports, some of the squirrels had been out for about two weeks. They were active, running about from burrow to burrow, and when surprised by an observer they were usually at some distance from home, even in a chilling wind or a drizzling rain. Of 8 specimens taken, 6 were males; 2, females. Contents of their stomachs showed that they were eating seeds of weeds and grasses, together with more or less green stuff. There was considerable fat left about the sexual organs and forward as far as the kidneys, particularly in the males. The two females were thinner. Weights and breeding conditions were:

Males, 6; average weight 174 grams; testes varying little from 9 x 16 mm. Females, 2; average weight 125 grams; horns of uterus 2 mm. in diameter.

It will be noted in connection with this data that the average weight of six males at the time of entering hibernation the previous summer was 222 grams.

These figures lack something of comparative value, however, in that no allowance was made in either case for food content of stomachs.

February 23–27, 1925.—The Townsend squirrels on the Kennewick flats were about in considerable numbers under varying weather conditions, but more generally in the calm and sunshine of morning or later afternoon. At such times they sit or lie in exposed situations where they will get the full benefit of the sun. The mating season was over. In most cases stomachs of the female squirrels taken were gorged with green food, while the males did not seem to be eating so heartily. This difference in feeding was probably due to the needs of the females, all of which were carrying young. Breeding condition and records at this time were:

Males taken, 19; average weight, 6 specimens, 160 grams; average size of testes 6 x 11 mm. (19 specimens). Females taken, 22; cases of pregnancy, early, 11; medial stage, 8; advanced pregnancy, 3; average number fetal sacs, 8.3.

As a matter of interest it may be noted that there was one case of a single, small resorbent fetus in this lot and another case of 4 fetal sacs, each 14 mm in diameter, and 4 fetal sacs, each 6 mm in diameter, in the same uterus.

Investigations of the ground squirrels on the east side of the Columbia River (*Citellus washingtoni washingtoni*) were undertaken on the same dates as above, February 23–27, on open patches in the sagebrush about Attalia and Wallula. This district is at a distance of only a few miles, and across the river, from the Kennewick country; but it has lighter soil, some shifting sand-blows, and no irrigation. Seasonal breeding conditions were somewhat farther advanced among these Washington squirrels than with the Townsend species across the Columbia. Breeding conditions and records of the species *C. washingtoni washingtoni* taken at this time were:

Males taken, 3; testes, each case, 5 x 10 mm.; average weight, 158 grams. Females taken, 11; cases of pregnancy, early, 1; medial stage, 1; advanced stage, 3; cases young already born, as indicated by fetal scars, 6; average number of fetal sacs, or scars, 8.

In this lot of the Washington squirrel there was one case of a single resorbent fetus, in medial pregnancy, and another case of two in advanced pregnancy.

March 26–30, 1925.—At Attalia and Wallula the young of the Washington squirrel were already out of their burrows in the warmer part of the day. Though still quite small, they were able to run about and feed on green stuff and to sit up and give the faint squeaky call of their kind. Sometimes instead of retreating to the family burrow when a little distance from home, they would seek refuge in shallow retreats from which they could be easily taken. An examination of their stomachs showed only green stuff. There was no curdled milk to indicate that they were still being suckled. Breeding and other physical data follow:

Adult males taken, 3; weights, respectively, 197, 197, 167 grams. Adult females taken, 8; all had suckled young earlier in the season. Young taken, 12; range of weights, 24–44 grams; average weight, 38.3 grams.

In the Kennewick country on these dates, March 26–30, young squirrels of the Townsend species were also out of the burrows, but in smaller numbers than with the Washington squirrel east of the river. It had been noted on the previous visit to the field that breeding stages of the westside squirrel lagged several days behind corresponding stages of the eastside species. Physical condition of the adult squirrels of both species, both sexes, showed improvement since the passing of the breeding season. Reproductive organs in both sexes were now reduced to such proportions that they were scarcely more than recognizable. Data on the Townsend species:

Adult males taken, 6; average weight, 177 grams; range 147–222 grams. Adult females taken, 10; all had suckled young; average weight 175.2 grams; range of weights 150–195 grams.

April 21–27, 1925.—Even at this early date family groups of the two species of squirrel seemed to be generally broken up, the young and the adults scattered about wherever food and shelter were available. Occasionally a small group consisting of the mother and two or three young was observed. Foraging trails were conspicuous, sometimes many rods long. The young squirrels were harboring in temporary shelters, about sluice boxes of the irrigated fields, in old pocket gopher workings, and in abandoned badger diggings. Not uncommonly they climbed to vantage points for observation—on sagebrush or flumes. Eight young squirrels were taken in digging out about 50 feet of shallow runs of the pocket gopher after these had been fumigated with carbon bisulphide. Data on the Townsend squirrels:

Young males taken, 5; range of weight, 80–122 grams; average weight, 101 grams. Young females taken, 6; range of weight 70–112 grams; average weight, 94.5 grams. Family excavated in treated burrow: female, 185 grams; average of 7 young, 63 grams.

It should be noted, in connection with weights of young or adult squirrels taken in the field, that figures may or may not be discounted to allow for recent ingestion of food in foraging. In the family excavated in a burrow weights of six of the young were, respectively, 60, 61, 62, 57, 60, 61 grams, while the seventh, gorged with green food, weighed 81 grams. The stomach alone in this specimen weighed 22 grams. Oddly enough, this young squirrel had been away foraging when the burrow was fumigated and had returned to dig into the home quarters and perish with the others. Data relating to specimens of *Citellus washingtoni washingtoni* taken at this time in the Wallula-Attalia district are given here:

Adult male, taking on fat, weight, 257 grams; adult female, 240 grams. Young, 8, weights, respectively, 110, 139, 111, 89, 127, 118, 128, 104 grams.

May 23–28, 1925.—At this time the semi-desert vegetation was blooming and seeding profusely and the squirrels, young and adult without obvious distinction, were feeding early and late but were less active in the hot noon

hours. The fare consisted mainly of succulent stems, buds, seed pods, and seeds—these from mallow, plantain, brome grass, bunchgrass (*Agropyron*), mustard, and, to a limited extent, from cultivated grains when such were available.

The squirrels are quite deft in the use of their front feet to secure food by reaching up and pulling down or bending over the plant stems and branches. Sometimes they feed while standing erect, but more often they pull the stuff down or cut it off so that they may assume a more comfortable position while eating. More frequently the food is eaten at the spot where it is secured, but sometimes stems of plants and heads of grain are carried to a burrow entrance or other place of greater security than the open range.

At this season, last week in May, it is difficult to distinguish the well-grown young squirrels from the mature adults, as organs and structures are subordinate to stored fat. Many of the later born are still, however, noticeably smaller than the older squirrels and the stored fat is white, rather than cream tinted as in the adults. This fat, which is to sustain life during the long period of aestivation and hibernation, is stored in considerable quantity in the visceral cavity from the kidneys back, but in greater mass under the skin of the back, hips, and shoulders. Records pertaining to the physical condition of the two species of squirrel at this season, follow:

Citellus townsendii townsendii.—Specimens taken, 14 Adult males, 5; average weight, 270 grams; range, 217–325 grams. Young males, 4; average weight, 144.5 grams; range, 128–170 grams. Adult females, 2; weights, 202 and 252 grams, respectively. Young females, 3; weights, 159, 147, and 193 grams, respectively. Weights of three stomachs of specimens dissected, 33½ grams each.

Citellus washingtoni washingtoni.—Specimens taken, 10. Adult males, 2; weights, respectively, 230 and 284 grams. Young males, 2; weights, respectively, 175 and 205 grams. Adult females, 3; weights, respectively, 275, 152, and 215 grams. Young females, 3; weights, respectively, 204, 179, and 180 grams.

From the above summaries several specimens of each species were omitted because of uncertainty as to whether they were breeding squirrels or young of the season. As all of the squirrels taken at this time were still feeding, there was no means of determining whether any had already retired to aestivation. It is assumed that those still abroad will entirely clear the intestinal tract before holing up. Fresh badger diggings were noted in three or four localities, although the burrowing was nowhere extensive.

June 17–29, 1925.—Eight squirrels of the Townsend species were taken in the hills south of Kennewick for hibernation studies. All of them were apparently young of this season. Only a few stragglers of the species were observed in the Kennewick locality after June 20 and these also, from their appearance and behavior, seemed to be young. *Citellus washingtoni washingtoni* had entirely disappeared from its known haunts about Wallula and Attalia. The burrows all showed neglect and disuse at the surface. In sexing the

eight squirrels of the Townsend species, while dormant in the hibernation studies, all were found to be males.

January 25–30, 1926.—During this third season of contacts with the ground squirrels of the Four-rivers country some observations not previously duplicated in this paper will be of interest. On the morning of January 28 a light snowfall covered the ground but this did not appear to discourage activity among the squirrels. A number of the animals were seen running about over the snow and scratching for food about the roots of the bunchgrass.

March 6–9, 1926.—Of seven squirrels, *C. washingtoni washingtoni*, taken at Wallula on these dates, all proved to be females. One had recently borne young, the others had been suckling young for some time. Three young squirrels, their eyes not yet opened, were found feebly crawling about near a burrow entrance where one of these females had been trapped the previous day.

April 13–15, 1926.—Ten squirrels were taken by trapping and six by shooting in the colonies about Kennewick. It may be noted here that squirrels of either of the species under consideration were easily taken alive in tilting-floor or spring-floor traps baited with apple, at any time when active. When transferred to a gunny bag from live traps they may be handled with little trouble by cornering them in the folds and then grasping them by the back of the neck. Rectal temperatures of squirrels taken immediately after shooting almost invariably registered, by clinical thermometer, between 101 and 102 degrees Fahrenheit.

May 20–27, 1926.—At this time all the old squirrels as nearly as could be determined, both males and females, had withdrawn more or less permanently into aestivation. At any rate none was taken or observed in the Four-rivers country during a stay of a week in the field. The young of both sexes were abroad, however, and quite active. They were feeding early and late and attaining growth as well as putting on fat.

March 3–6, 1927.—Principal attention was given this season to studies of dormant squirrels in artificial hibernating enclosures, but a few field notes are of particular interest. At the time of this visit squirrels were reported to have been out for at least three weeks in the Kennewick country, and two observers while hunting on January 2 noted a quirrel running about on the snow. A female of the Townsend species, trapped alive on March 5, gave birth to 7 young on the trip back to headquarters at Puyallup. The young were naked and blind little creatures that did considerable fussing and squeaking in the cage with their mother—on a Pullman car.

On a later trip to the Kennewick country, March 30–31, about a dozen family groups of the Townsend squirrel were under observation at times, among them a family of ten including the mother. In this group some of the young were busy nibbling grass and other herbage, while at the same time two others were suckling, lying on their backs as they did so. In the other groups at least some of the young were actively feeding on plant tissues.

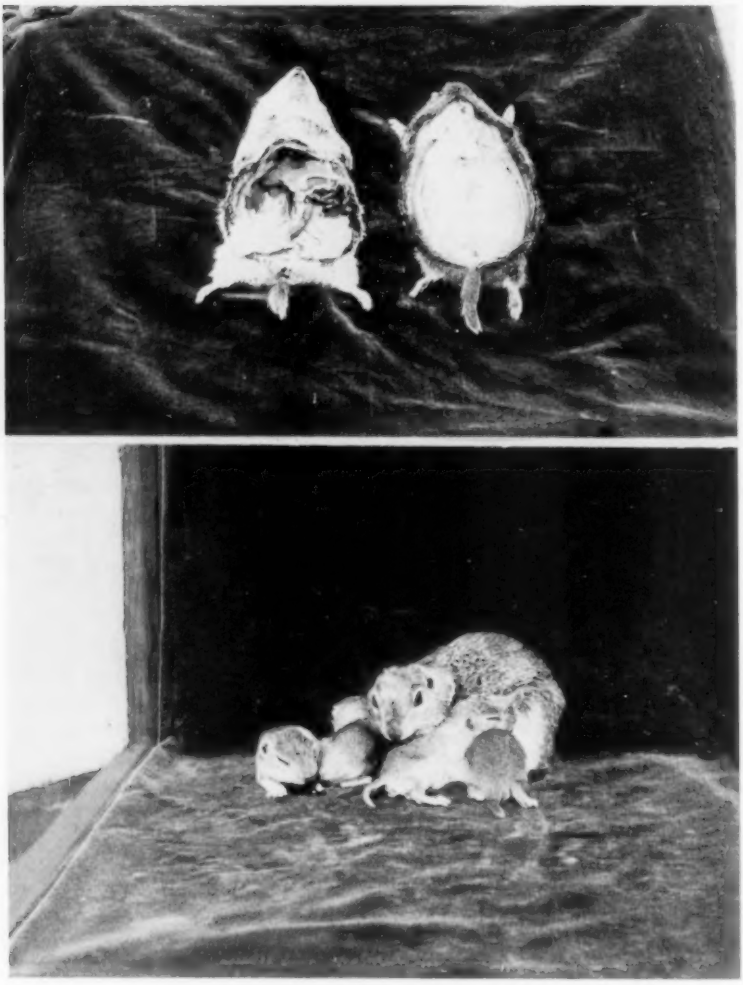

PLATE 2

UPPER: Specimens of male Townsend ground squirrels showing masses of fat in the visceral cavity and beneath the skin of the back. Photographed May 29, 1925.
LOWER: Female Townsend ground squirrel and young 18 days old from Kennewick, Washington. Photographed March 28, 1927.

SUMMARY

1. Habitat conditions: Elevation about 300 feet; cover mainly of sagebrush and bunch gass; Upper Sonoran life zone.

2. Emerge from hibernation, late January and early February; males first.

3. Enter aestivation, late May and early June (adults); late June (juv.)

4. Mating polygamous, in early February; young born in early March.

5. Young emerge from burrows in late March; half grown in late April.

6. Townsend squirrel (*Citellus townsendii townsendii*). Average number of fetuses (52 specimens), 8.6; range in number of fetuses, 4 to 16.

7. Washington squirrel (*Citellus washingtoni washingtoni*). Average number of fetuses (26 specimens), 8; range in number of fetuses, 5 to 11.

8. Testes of males in breeding season, 9 mm x 16 mm; out of season, 2 mm x 4 mm or even smaller.

9. Food of these squirrels consists mainly of succulent stems, roots, buds, seeds and pods of bunch grass (*Agropyron spicatum*), mallow, brome grass, plantain, mustard, and, to a limited extent, of cultivated grains and alfalfa when such crops are near their colony sites. On emerging from hibernation the squirrels greedily nibble the short, green grass or herbage.

10. The two species of squirrel are fairly easily distinguished by the maculate markings on the back of *C. washingtoni washingtoni* and its somewhat more bushy tail than *C. townsendii townsendii*. The latter has no pelage spotting.

U. S. Fish and Wildlife Service, Puyallup, Washington.

FOOD HABITS OF THE WHITE-THROATED WOOD RAT IN ARIZONA

By Donald A. and Alice L. Spencer

While in central Arizona, near Camp Verde, and in the southern part of that State near Tucson, the writers studied the ecology of the white-throated wood rat (*Neotoma a. albigula*). The mounded den of this species is one of the most typical as well as most interesting objects in the area. Counts of these dens varied from none to 20 an acre. This rodent reaches its highest population in vicinities where prickly pear cactus is abundant and may be entirely absent from pure stands of creosote bush or open grasslands.

Because the wood rat is often the most abundant rodent on Arizona rangelands, questions as to possible competition with cattle for forage and as to spread of the cacti with which they are always associated are of interest to cattlemen. During periods of drought or of overgrazing by cattle, most grasses that survive are in the shade of cacti or thorny shrubs. Here these grasses, so important in natural range recovery, though protected from livestock, can still be reached for food by wood rats and other rodents. Some persons have contended that these rats are thus the "last straw" in range destruction, and that they should be reduced in numbers during critical periods by artificial means. The spread of cactus, cholla in particular, has created a perplexing problem of range management and the wood rat has been given a share of the blame. The food habit study here reported was an attempt to clarify these problems.

Five hundred wood rat dens were opened and examined in the Verde Valley and a larger number in the Tucson area. Cactus forms the largest bulk in the food of this rodent and ranks first in importance. Prickly pears are favored over chollas, both as food and as den sites. When there is no fruit on the plants, dens of wood rats among prickly pears can be located by the white scars on the partly eaten joints of the plants. The tops of all rat dens, where ripe fruit is available, from September to November in the Tucson area, bear a mass of partly eaten and fermenting fruit. During this period it is unusual to trap a wood rat whose mouth and entire alimentary tract are not stained a bright purple.

Fresh and partly eaten joints of cholla are common in the dens during the prickly pear fruiting season. Cholla fruits, abundant and available throughout the year, are not eaten to any extent during the prickly pear season, but shortly thereafter they are commonly taken.

Food preference tests with 61 individually caged wood rats supplemented field observations, 9 varieties of cacti being fed in 64 combinations. The food was weighed before being placed in the cage with the rat, and that which remained after a 24-hour period was weighed, the amount of each kind eaten being recorded. Each combination offered was in excess of the 24-hour rat

consumption. Reference to table 1 will show that the average daily consumption of cactus approximated 60 per cent of the wood rat's body weight.

Twelve wood rats each accepted on the average, 20 grams of joints and 84 grams of fruit of the prickly pear (*Opuntia engelmanni*) in 24 hours. Eleven rats given only fruits each accepted, on the average, 128.64 grams in 24 hours.

When joints of prickly pears (*O. engelmanni*) and cholla (*Opuntia mammillata, O. spinosior, O. fulgida*) were offered in combination they were quantitatively accepted in the following order: *O. mammillata, O. spinosior, O. engelmanni,* and *O. fulgida.* The fruits of these four cacti were taken almost in reverse order: *O. engelmanni, O. fulgida, O. mammillata,* and *O. spinosior.* Fruits of various prickly pears (*O. engelmanni, O. arizonicus,* and *O. phaeacantha*) are accepted more or less indiscriminately.

Joints of the chollas are eaten in greater quantity than are their fruits, whereas the opposite is true of prickly pears. Fruits of chollas are slightly more acceptable than are joints of prickly pears while fruits of prickly pears are much more favored than are either joints or fruits of chollas.

It is interesting to note differences in the feeding of the rats on various cactus fruits. In general, prickly pear fruits are eaten entire; the seeds pass undigested through the alimentary tract and are found whole in the feces. The fleshy parts of the fruits of certain chollas (*O. spinosior, O. tetracantha*) are discarded and the seeds are hulled and eaten. Of other cholla fruits (*O. mammillata, O. fulgida,* and *O. leptocaulis*) only the fleshy part is eaten, the seedy core being discarded.

THE SPREAD OF CACTUS

Forrest Shreve, Desert Laboratory of the Carnegie Institution, and J. J. Thornber, University of Arizona, have pointed out the following facts as to reproduction in cactus. Chollas and prickly pears are easily propagated by their joints which take root like leaf cuttings. Chollas are principally reproduced by this method. Because of their minutely barbed spines the joints become detached by the slightest contact with man or animal, and are often carried some distance, earning for the plant the popular name of jumping cactus. The fruits of certain cholla hang in heavy chainlike clusters that persist on the plants from season to season. When these fruit chains are broken off and fall to the ground, they also take root in the same manner as the joints, producing a new plant without ever a seed in their inner core having sprouted. Prickly pears, on the other hand, have heavy joints and long barbed spines. While these joints may be broken off from the parent plant they are not carried away on fur or clothing. Shreve has stated that it is likely that the majority of new plants of prickly pears start from seeds. He points out, however, that the hull of the seed is extremely hard and resistant to rot, requiring, on the average, 3 years to sprout in favorable soil.

Beneath the shelter of a prickly pear cactus in the fall the ground is covered

with seeds that have passed through wood rats, for the animals in feeding do not leave the protection of the plant. Feces containing undigested seeds, however, are deposited also beneath any shrub or cactus shelter reached by the rat trails. Many species of birds and mammals (including cattle) also feed on prickly pear fruits, and they distribute undigested seeds far and wide. The wood rat plays but a minor role in the spread of cactus seeds.

The wood rat carries skeletonized dead joints, which are dry and light, to its den as construction material, but does not transport fresh green joints in this way. The rat habitually feeds on prickly pear joints still attached to the plants. There is no evidence that it stores this kind of food as it does the joints of chollas. In one experiment four freshly cut joints of prickly pear were placed under thorny shelter not ten feet from a wood rat den. The rat fed on one of the joints but failed to carry them away during the period of observation.

Seed reproduction not being important in chollas, vegetative reproduction need only be considered. Normally, remote from wood rat dens, the ground beneath these plants is littered with green and dead joints and fruits. The amount of this kind of reproduction is often astounding. In the vicinity of a den, however, the ground beneath cacti reached by wood rat trails is devoid of green or dead joints and fruits. Reproduction beneath a rat-cleaned cholla is in inverse proportion to exposure to the rat's residence nearby. To test the gleaning activities of the wood rat, freshly cut joints of cholla, of the common three species, were placed under mature plants from 5 to 25 feet from rat dens. The joints at a placement numbered 5 to 20 and each was marked with a piece of white twine. In no case did a rat fail the first night to carry a number of the joints to its den. Ten was the greatest number transported in any one night. It was usual for at least one of the joints to be partly eaten at the den site. To determine also whether the wood rats cut joints from the plants themselves or relied principally on dropped joints, whole limbs from chollas were placed on the ground beneath cactus shelters. A large percentage of the cactus material so placed was nibbled upon but in no case did the rats cut off joints or fruits.

Thus it would seem that, far from being a factor in the spread of chollas, the white-throated wood rat tends to restrict reproduction of the plant. Not too much emphasis should be placed on this influence, however, as the peak infestation of 20 rats an acre failed to keep more than a portion of the area cleaned up.

The wood rat commonly lines both sides of its trail with cactus joints for some distance, and investigators have suggested that these joints may take root and form new colonies. Field observations, however, show that this rarely occurs. Green cactus joints are used primarily for food and secondarily for protection, and for this reason are carried to the den. Dry and withered joints form these trail-protecting borders. Again, green joints are

almost always stacked on top of dry debris that prevents them from coming in contact with the soil and germinating.

FOOD STORAGE IN DENS OF THE WOOD RAT

Aside from cactus, green leaves of various thorny shrubs, mesquite, catclaw, acacia, and hackberry, form the next most common food stored in dens. The amounts found varied from a few fresh leaves to 2 quarts of tightly packed dried leaves. In season the fruits of these shrubs also are commonly stored. As much as 2 gallons of dried mesquite pods have been found in a single den. Catclaw beans were second in rank in this type of food. More than a pint of the fresh orange-colored berries of the desert hackberry have been taken from a single den. Although excellent climbers, woodrats have not been observed to gather dry mesquite pods from the tree itself, but they carry away every pod or cluster that falls to the ground. They also store the seeds of a number of small leafy annuals and of several species of desert gourds.

The following is cited as a typical example of den-food storage. The den, examined November 8 at Tucson, Arizona, was in a small fruitless prickly pear cactus and was constructed almost entirely of joints of chollas (*O. fulgida*, *O. spinosior*). It was surrounded by grasses, four large desert hackberry bushes, many chollas of three species, and there was a mesquite tree within 20 feet. Food fragments in the den consisted of (1) empty yellow fruit pods of cholla (*O. spinosior*), (2) fruits of prickly pear, (3) numerous hackberries, and (4) about 2 gallons of dry mesquite pods.

In cage tests two wood rats ate 19 grams and 17½ grams of mesquite leaves, respectively, in a 24-hour period.

GRASS AS FOOD FOR WOOD RATS

Caged rats accepted every variety of range grass offered, and this despite the fact that an excess of cactus and mesquite foods was also available. Although special effort was made to examine dens in good grass cover, no grasses were found stored in 1,000 dens examined. These findings are not duplicated for any other food that forms an appreciable item in the diet.

In the Verde Valley all but one of the 500 dens studied contained nests made of grass. In one large area den construction included the roots and crowns of *Hilaria* and *Aristida*, two of the most common grasses of the area. At least a bushel of the crowns of these grasses might have been collected from each den. It could not be determined whether these had been loose dead tufts gathered by the rat, or whether they had been removed from dormant but living turf, and thus represented damage to the range.

Walter P. Taylor and Charles T. Vorhies collected 360 wood rat stomachs, 30 for each month of the year, from the Santa Rita Range Reserve, Pima County, Arizona, which were examined by the Food Habits Section of the Biological Survey. Their report shows that although grass constituted 4.81

per cent of the food of the animals throughout the year, it never exceeded 10.54 per cent of the food by bulk for any one month.

In commenting on stomach-collection work of this kind it should be remembered that as no grasses are stored within the den the animals do not have an opportunity to eat grass while they are "holed up". Yet a certain amount of feeding on stored materials must take place during the day, for the stomach weights collected at 4:00 p.m. are comparable to those collected in the forenoon. The common practice in taking wood rats now is to set traps in the late afternoon, the rats being caught overnight. When traps are well set the rat is caught shortly after it emerges from the den and before it has had much opportunity to feed on standing grasses. Thus trapping to determine their consumption of grasses should be done after 10:00 p.m.

Observers agree that often a heavy stand of grass occurs about an old established den of the wood rat, as shown in figure 1. The seed heads of these grasses are not lopped off nor is there any other evidence that rats feed upon them. The experiment to be described, however, indicates that wood rats do have an influence in keeping down stands of grass. The study was made on a 5-acre tract near Tucson, Arizona, on which there were 105 wood rat dens in use. This area was trapped free of the animals and maintained in that condition by regular bi-weekly trapping. Trap sites were permanent and marked by stakes. Toward the end of a 9-month period of observation the growth of grass and annuals was so heavy that it became necessary to move many of the traps to other positions in order to place them in open lanes traveled by reinfesting rodents. The test did not apply to wood rats alone, as all rodents were removed. Rabbits, carnivores, and cattle, however, were not disturbed.

Data thus far collected do not indicate undue pressure on range grasses in Arizona by the white-throated wood rat. Nevertheless, this conclusion may sometime have to be revised as this rodent shows great adaptability. Under conditions that curtail the normal food supply it is quite likely that grass might become more important in the rat's diet, to the detriment of the range. Food habits problems characteristically vary with locality and season.

ACKNOWLEDGMENTS

The writers wish to acknowledge the supervision and assistance of F. E. Garlough, Director of the Control Methods Research Laboratory (now Wildlife Research Laboratory) of the Fish and Wildlife Service at the time the studies were made. Forrest Shreve of the Carnegie Institution and J. J. Thornber of the University of Arizona, helped immeasurably in identifying plants and discussing ecological relations. Walter P. Taylor, Fish and Wildlife Service, and Charles T. Vorhies, University of Arizona, who studied this wood rat for many years, gave us the benefit of their experience and data. B. E. Ludeman assisted with the field work.

U. S. Fish and Wildlife Service, Washington, D. C., and R. F. D. no. 3, Poughkeepsie, New York.

MELANISM IN THE FELIDAE, WITH SPECIAL REFERENCE TO THE GENUS LYNX

By Fred A. Ulmer, Jr.

On April 18, 1939, Vincent Nelson and J. Townsend Sackett trapped alive a melanistic Florida bobcat (*Lynx rufus floridanus*) in Martin County, Florida, about fourteen miles above the mouth of the Loxahatchee River. Nelson, who has had much experience trapping in sub-tropical Florida, said that although he had secured many bobcats this was the first black one he had ever seen.

This specimen, a male, was secured by Sackett for the Zoological Society of Philadelphia and it was exhibited at the Philadelphia Zoological Gardens from the latter part of April to August 3, when it died of hemorrhagic enteritis (distemper). The skin and skull were preserved and are now in the mammal collection of the Academy of Natural Sciences of Philadelphia (no. 19842).

In January, 1940, Nelson secured another melanistic bobcat in the same area. This one, a female, was captured unhurt in a steel trap in the swampy cypress jungle between the mangrove belt along the Loxahatchee River (called Jupiter River by the Government Hydrographic Office) and the open, sandy pine forest farther inland. The place of capture is about two miles above the locality where the first specimen was taken and close to the point where Kitchen Creek joins the Loxahatchee. Dr. Raymond L. Ditmars obtained this second specimen for the Bronx Park Zoo, where it is now on exhibition.

The Academy specimen, upon close examination, is far from black. The most heavily pigmented portions are the crown and dorsal area. In most lights these areas appear black, but at certain angles the dorsal strip has a decidedly mahogany tint. The mahogany coloring becomes lighter and richer on the sides. The underparts are lightest, being almost ferruginous in color. The chin, throat and cheeks are dark chocolate-brown, but the facial stripes can be seen clearly. The limbs are dark mahogany. In certain lights the typical spot-pattern of the Florida bobcat can be distinctly seen on the sides, underparts and limbs. The Bronx Park animal appears darker and the spots are not visible, although the poor light in the quarantine cage may have been the reason.

Numerous white hairs are scattered through the dark dorsal strip in both animals. The normal bobcat's dorsal area is similarly sprinkled with white hairs, but in the light, grizzled pelage they are scarcely noticeable. A small patch of white hair occurs in the inguinal region of the Academy's specimen. The Bronx individual has a larger white inguinal patch.

The vibrissae of both specimens are pigmented, but scarcely more than may be seen occasionally in the whiskers of normal bobcats. The facial ruffs are short and inconspicuous. This peculiarity, together with their sleek, black fur, gives them the appearance of overgrown house-cats, especially when they are lying in a curled-up position with their long legs hidden. Both

PLATE 1

Melanistic male bobcat (*Lynx rufus floridanus*) from Martin County, Florida. Photograph taken at the Philadelphia Zoo by Mark Mooney, Jr.

animals have extremely long tails for bobcats. No. 19842 has a tail more than seven inches (180 mm) long and the Bronx specimen has a tail of approximately seven inches (estimated). Because of these features it has been suggested that they are the hybrid offspring of a wildcat and a domestic cat. This possibility must not be disregarded for, in *Thalarctos* and *Ursus*, closely related genera, hybridization has taken place and the genus *Lynx* has close affinities with *Felis*. However, for numerous reasons, I feel certain that this is not a case of hybridization.

The animals' tails while long, are not excessively so. Seton in "Lives of Game Animals" records a Saskatchewan bobcat with a tail of 177 mm (7 inches) and the tail of an Academy specimen from the Okefenokee Swamp in Georgia measures 167 mm (6⅝ inches).

Apparently these are the first records of melanism in the genus *Lynx*. After a fairly exhaustive search through the literature, the only approach to melanism in *Lynx* that I can find is a light brown European lynx (*Lynx lynx*) mentioned by Poland (1892). Albinism, too, is apparently rare in these animals. Poland mentions an albino bobcat (*Lynx rufus*), but since his material evidently was commercial furs, we cannot be certain that this was a true albino. Miss Viola Schantz (1939) recently described a Washington bobcat with white fore-feet. Tabbied specimens occasionally occur and there is such a specimen from Coleraine Plantation, Georgia, at the Academy of Natural Sciences. In it the spots of the sides have fused into elongated blotches resembling those of the ocelot (*Felis pardalis*). From the existing evidence it would seem that the genus *Lynx* has little tendency toward mutation, but keeps close to type.

True melanoids, such as these Florida bobcats, are produced by a deepening of the ground color so that even the underparts are affected. Opposed to these are pseudo-melanoids such as *Felis pardus melanotica* Günther from Grahamstown, South Africa, and the Striped Cheetah (*Acinonyx rex* Pocock) from Southern Rhodesia. In them the darkening is effected by a fusion of the spots, tending to eliminate the ground color; but in all these instances the underparts and other areas, where the ground color is not obliterated, remain normally colored. Into this category falls a leopard skin described by Collins (1915) from the Malabar Coast of India. The spots of the sides were fused into long, stripe-like areas and those of the dorsal area were fused into a solid black mass.

It is perhaps not surprising that melanism should occur in the Florida bobcat for it is the darkest form of *Lynx rufus*. Few cases of melanism in the Felidae have occurred outside the tropics or sub-tropics and rarely even there in dry, arid regions. Black leopards are common in the moist, evergreen jungles of Malaysia, but few are recorded from Africa where much of their range is in comparatively dry country. The genus *Lynx* ranges widely through the temperate and arctic parts of the Northern Hemisphere but reaches the sub-tropics only in Mexico and Florida. Although it reaches a

point much farther south in Mexico, its habitat there is the elevated, semi-desert plateaus of the interior. Only in Southern Florida, of its entire range, does it encounter conditions which approximate those under which melanistic races of several Felidae have been produced in other parts of the world.

Melanism is well known in the leopard (*Felis pardus*), and it has occurred in many other cats of tropical distribution. There are records of black tigers from India. The golden-cat (*Felis temminckii*) shows considerable tendency toward melanism and numerous black specimens have been recorded. Shortridge (1934) lists four records of melanism in the African serval (*Leptailurus serval*). The caracal (*Caracal caracal*), usually associated with dry, arid country, would not be expected to have melanistic tendencies and there is apparently only one record, a South African individual. Melanism is occasionally found in the jaguar, and even now there is a fine specimen in the New York Zoological Society's collection. The spot-pattern is perfectly clear against the black ground color. In Central America, *Felis carrikeri* Allen was based on a melanistic specimen of a leopard-cat.

In the case of the Felidae, we apparently have evidence that warmth and moisture are factors in producing melanism. Prince (1913) wrote, "Damp and warm conditions result in darkening the fur or plumage and the external color of animals generally". He further quoted Beddard, saying, "Melanic varieties, as they are termed, often occur on islands and other situations where the climate is moist as well as warm." Sumner and Swarth (1924) have proven, in the case of certain rodents at least, that the optical qualities of the background have little effect on coat color, but rather that climatic factors are responsible for changes. Melanism is easily described as the presence of the pigment melanin, but certainly much remains to be done in explaining it and in discovering the factors that produce it.

I wish to thank Dr. Raymond L. Ditmars for his kindness in permitting me to examine the Bronx Park specimen. I am grateful to the Philadelphia Zoological Society and to Mark Mooney for data and pictures of the male black bobcat and to Mr. J. Townsend Sackett for details of the capture of these animals in Florida.

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Academy of Natural Sciences, Philadelphia.

SOME NOTES ON UTAH BATS

By Ross Hardy

Because there are so few records of Utah bats, it is the purpose of this paper to list those species known from the state according to published records, to indicate other species which should be found in Utah, and to list records and notes regarding a collection of specimens recently studied.

The writer wishes to express thanks to Dr. William H. Burt of the Museum of Zoology, Ann Arbor, Michigan, for his suggestions regarding certain specimens. My thanks are also given to Gerrit S. Miller of the U. S. National Museum for comparison of specimens of *Myotis lucifugus phasma* with type material. I wish to thank S. D. Durrant and Dr. A. M. Woodbury of the University of Utah for the use of 44 skins and skulls; Dr. Vasco M. Tanner, Brigham Young University, Provo, Utah, for the loan of 18 formalin specimens from their collection, and Merle V. Walker, Zion National Park, for the use of 12 specimens. The remaining 131 specimens of the 205 examined are either at Dixie Junior College or in the writer's collection.

In the following list, the University of Utah specimens are indicated by U, the Brigham Young University material by Y, the Zion National Park Museum material by Z, and those not otherwise designated are at Dixie Junior College. Names of Utah counties appear in capital letters.

Myotis lucifugus carissima Thomas.

Records: Miller and Allen (1928, p. 52): BOXELDER, Mouth of Bear River, 20; DAVIS, Bountiful, 1; UTAH, Provo, 1.
Specimens examined: None

Myotis lucifugus phasma Miller and Allen.

Records: None from Utah. This race was named from one California and three Colorado specimens.
Specimens examined: JUAB, Burriston, 6. (One given to U)

On August 16, 1935, two of these bats were taken as they flew from beneath door frames and from the attic of a large farmhouse. Two nights later another one was obtained. They were caught from the air with an insect net as they began flight. Using the net on June 21, 1939, two females and a male were taken in the attic of the same farmhouse. Many large clusters of *Eptesicus fuscus pallidus* were hanging in the attic, but they left soon after sunset. At dusk, the *phasma* bats came, one by one, from small cracks beneath shingles and from small tunnels along the ridge of the roof into the attic, and were taken as they fluttered about seeking escape through one of the numerous cracks.

Inasmuch as there are so very few specimens of this race reported for the United States, measurements of the six specimens are given: Total length: 89.8 (97-86); tail vertebrae: 37.8 (41-35); hind foot: 10.2 (12-9); ear from notch: 13.6 (15-12). One female (no. 1611) collected June 21, 1939, contained two small embryos.

Myotis yumanensis yumanensis (H. Allen)

Records: Miller (1897, p. 67) UTAH, Provo, 1.
Specimens examined: WASHINGTON, Apex Mine, 1; Saint George, 1.

A poorly preserved formalin specimen in the Dixie College collection was taken at Apex Mine in the Beaverdam Mountains, according to Dr. D. E. Beck, whose students collected the specimen. No date is given in the records. The other specimen was taken September 9, 1940, from a corner of a small room in the Gymnasium Building at Dixie College.

Myotis yumanensis sociabilis H. W. Grinnell

Records: Miller and Allen (1928, p. 62) state that intergrades between *sociabilis* and typical *yumanensis* are to be expected in central Utah, but they had no Utah specimens.

Specimens examined: None.

Myotis velifer incautus (J. A. Allen)

Records: Miller and Allen (1928, p. 98): UTAH, Thistle Valley, 2.

Specimens examined: None.

Myotis evotis chrysonotus (J. A. Allen)

Records: Miller and Allen (1928, p. 122) show all of the state in the range of this bat, but no Utah specimens were listed.

Specimens examined: SAN JUAN, Verdure, 1, U; WASHINGTON, Zion National Park, 1, U; Saint George, 1, Y.

The Verdure specimen was collected May 10, 1933, while the others were taken in August and September respectively. The Zion Park specimen was procured from a tent in the campground.

Myotis thysanodes thysanodes Miller

Records: Miller and Allen (928, p. 122) show that the entire state is in the range of this species but gave no Utah records.

Specimens examined: None.

Myotis volans interior Miller

Records: Benson (1935, p. 448): SAN JUAN, Near Rainbow Bridge National Monument.

Specimens examined: CARBON, Price, 2 males.

One bat was found on the lawn at Kiwanis field about 3 p.m. April 26, 1938. The other was shot in flight on the evening of August 20, 1938.

Myotis californicus californicus Audubon and Bachman.

Records: Tanner (1927, p. 250): UTAH, Aspen Grove on Mount Timpanogos, 3. Miller and Allen (1928, p. 149) include northeastern Utah in the range of this species but had no Utah specimens.

Specimens examined: None.

Myotis californicus pallidus Stephens

Records: Miller and Allen (1928, p. 149): KANE, Kanab, 1.

Specimens examined: CARBON, Sunnyside, 1; WASHINGTON, Saint George, 2.

Unfortunately the Carbon County bat and one of the other formalin specimens have faded considerably, so much so that the pelage color cannot be accurately determined. They belong to the species *californicus* and are listed with the race *pallidus* because of the region in which they are found (See Miller and Allen, 1928, p. 149) The other skin is in good condition.

Myotis subulatus subulatus (Say)

Records: Miller and Allen (1928, p. 165) indicate UINTAH and DAGGET Counties are in the range of this animal, but they possessed no Utah specimens.

Specimens examined: CARBON, Soldier Canyon, 2.

The specimens examined were taken June 30, 1940, by Harold Higgins as they flew over a pond. They were in the company of *Lasiurus cinereus*.

Myotis subulatus melanorhinus (Merriam)

Records: Woodbury (1933, p. 174): WASHINGTON, Zion National Park. Presnall (1938, p. 6): Zion National Park, common.

Specimens examined: EMERY, Ferron, 1, Y; GRAND, One mi. E Moab Bridge, 1, U; KANE, 4 mi. N Kanab, 2; WASHINGTON, Zion National Park, 4 (2U and 2Z); Saint George, 1.

The two specimens from Kane County were taken January 27, 1940, from the walls of Crocodile Cave where each hung singly above the water. Their nearby companions in hibernation were the more numerous *Corynorhinus rafinesquii pallescens*. Two of the Zion Park specimens were taken at the campground on August 5, 1931. The Grand County specimen was obtained April 10, 1934, while the Emery County bat was found in October.

Lasionycteris noctivagans (Le Conte)

Records: Miller (1897, p. 86) placed the entire United States in the range of this species. Barnes (1927, p. 21): SALT LAKE, Big Cottonwood, 1.

Specimens examined: SALT LAKE, Salt Lake City, 1, U; EMERY, Gunnison Butte at Green River, 1, U; GRAND, Bridge over Colorado River at Moab, 1, U; CARBON, Sunnyside, 2; WASHINGTON, Leeds, 1; Saint George, 2.

Each of these bats was taken singly. One was found in Whitmore Canyon near Sunnyside May 18, 1936, as it hung on the side of a large boulder near the water. The Salt Lake City specimen was taken on the University of Utah Campus October 5, 1936. One of the Saint George specimens, taken October, 9, 1939, was in a garage while the other was found the morning of December 14, 1939, hanging on the stone wall at the entrance of the Woodward High School building. It seemed in semi-hibernation in the chill of the morning air.

Pipistrellus hesperis hesperis (H. Allen)

Records: J. A. Allen (1893, p. 83): SAN JUAN, Riverview, 3; Miller (1897, p. 90): WASHINGTON, Saint George, 2; Stanford (1931, p. 362): Garfield King's Ranch at base of Henry Mountains, 1; Benson (1935, p. 448): SAN JUAN, Navajo Mountain region, common; Hatfield (1926, p. 258); Navajo Mountain area.

Specimens examined: GRAND, 5 mi. E of Moab Bridge, 10, U; SAN JUAN, One-half mi. N Bluff, 2, U; KANE, Willow Springs Tank, 4, Y; WASHINGTON, Saint George, 8.

Most of these bats were taken from early in April to late in June, but on January 29, 1940, one was shot from the air as it fluttered with others over a swamp near the junction of Santa Clara Creek and Virgin River south of Saint George. The temperature was 47°F. at dusk. These bats may occasionally be seen in the Lower Sonoran Zone on warm evenings in winter. Usually they seem to hibernate in cracks and crevices of ledges, but April 5, 1939, one was taken from beneath a rock about a foot in diameter. A large chuckwalla lizard (*Sauromalus obesus*) was beneath the same rock on this warm spring day. Another specimen was found in the morning in the hall of the Education Building at Dixie Junior College.

Eptesicus fuscus pallidus (Young)

Records: (Of *Eptesicus fuscus*): J. A. Allen (1893, p. 83: SAN JUAN, Bluff, 2; Miller (1897, p. 98): CACHE, Laketown, 1; WEBER, Ogden, 5; WASHINGTON, Saint George, 4; Stanford (1931, p. 363): CACHE, Logan, 4; SEVIER, Salina, 2.

(Of *Eptesicus fuscus fuscus*): Long (1940, p. 172): BEAVER, 2 mi. E Beaver, colony; MILLARD, Fillmore, colony.

(Of *Eptesicus fuscus pallidus*): Benson (1935, p. 448): SAN JUAN, Navajo Mountain Trading Post, 1; Presnall (1938, p. 6): WASHINGTON, Zion National Park, common.

Specimens examined: SALT LAKE, Salt Lake City, 2, U; CACHE, Hyrum, 1, U; GARFIELD, 5 mi. W Escalante, 3, U; Summit of Table Mountain 20 mi. NW Escalante, 1, Y; JUAB, Burriston, 13; BEAVER, Beaver, 6; WASHINGTON, Apex Mine, 2; Santa Clara, 1; Saint George, 3; EMERY, Green River, 6; GRAND, 4 mi. N Elgin, 1.

There seems to be some uncertainty regarding which race, *fuscus* or *pallidus*, is prevalent in Utah. As listed above, only Benson and Presnall have considered their material as being *pallidus*. All of the material examined in this study seems referable to the subspecies *pallidus*. Three immature specimens in the University of Utah collection (Nos. 1456, 1484a, and 2252) are darker than most but are paler than typical *fuscus* from Michigan. All other specimens examined are much paler and larger than typical *fuscus* although there is individual variation.

The two specimens taken at the Apex Mine in Washington County on March 9, 1940, were the only animals of this species among the many *Corynorhinus r. pallescens* hibernating there at that time. Both were males and each was hanging singly. The specimens from Juab County were taken from the attic of a building which is still used as a human dwelling place. Only females and their young were found in the large clusters examined. The young were so large that they were not carried by their mothers in flight on June 21, 1939. The specimens from Beaver were taken from a narrow crack between a rock wall of a house and the framework of the attached wooden porch. On July 21, 1939, the females and the immature males were not in clusters in this situation. Specimens collected from a large flock in flight over an alfalfa field south of Saint George at dusk on June 27, 1940, proved to be *E. f. pallidus* and the smaller *Pipistrellus h. hesperus*.

Lasiurus borealis teliotis (H. Allen)

Records: Presnall and Hall (1936, p. 211): WASHINGTON, LaVerkin Cave, 7.

Specimens examined: CARBON, Kenilworth Mine, 2; WASHINGTON, Saint George, 2; LaVerkin, 7, Z.

The two Kenilworth specimens were found September 17, 1937, hanging on the walls of a mine not far from the entrance. One of the Saint George specimens is a dried mummy picked up from the ground near the Virgin River on May 6, 1940.

Lasiurus cinereus (Beauvois)

Records: Coues and Yarrow (1875, p. 91): UTAH, Thistle Valley, 2; H. Allen (1893, p. 162): "La Boule River, Utah" (?)

Specimens examined: DAVIS, Bountiful, 1, U; SALT LAKE, near Salt Lake City, 1, Y; CARBON, Soldier Canyon, 1; GRAND, 4 mi. N Elgin, 1; WASHINGTON, Hurricane, 1, U; Saint George, 2.

These bats are taken singly from brush or trees where they hang at rest. The specimens from Washington County were taken from May 4 to September 5. The Carbon County specimen was shot while flying over a pond. They probably migrate before winter.

Euderma maculatum (J. A. Allen)

Records: Durrant (1935, p. 226): SALT LAKE, Granite district, 1.

Specimens examined: None

Bernell McAllister of the Soil Conservation service at Saint George reports that in February, 1930, he collected four big-eared "black and white pinto" bats in Crocodile Cave four miles north of Kanab in Kane County. He observed that they were hibernating on the walls of the cave above the large pool of water. They hung by the thumb with the head up and not head downward as do other bats, according to Mr. McAllister. Subsequent visits failed to reveal others. The writer visited this cave with Mr. McAllister January 28, 1940, and found only *Myotis subulatus melanorhinus* and *Corynorhinus rafinesquii pallescens* near the entrance, but we did not have a boat and could not examine the bats on the walls deeper in the cave. Ray Porter, student at Dixie Junior College, reports that during the summer of 1939 a large eared "pinto" bat was found on his sleeping porch at Hatch in Garfield County. At that time he did not realize its value and it was liberated.

Corynorhinus rafinesquii pallescens Miller

Records: H. Allen (1893, p. 60): (as *C. townsendii*) Utah, 7; Miller (1897, p. 53): Utah, 1; Woodbury (1933, p. 174): WASHINGTON, Zion National Park, common; Long (1940, p. 172): BEAVER, east of Beaver, colony.

Specimens examined: SAN JUAN, Bluff, 7, U; SANPETE, Wales, coal mine in Pete Canyon, 7, U; UTAH, old mine shaft east of Springville, 1, Y; CARBON, Range Creek, 1; Sunnyside, 1; EMERY, coal Mine in Horse Creek Canyon, 1; KANE, 4 mi. N Kanab, 4; WASHINGTON, abandoned mine shaft on Mineral Mountain, 1; Apex Mine, 16 (2 Y); Bloomington Cavern, 1.

As indicated above, these bats are most common in mines or caves. Even shallow prospect-holes usually contain one or more of this race. One female was found in the attic of an abandoned house at Range Creek in Carbon County. They usually hang singly but sometimes as many as four or five females are found in one cluster. During the coldest period of hibernation, the large ears of this bat are folded back revealing the interior. In Utah they hibernate throughout the winter.

Antrozous pallidus pallidus (Le Conte)

Records: J. A. Allen (1893, p. 83): (As *A. pallidus*) SAN JUAN, Bluff, 2.

Specimen examined: CARBON, Price, 1.

This specimen was taken by Robert Pendleton, Dixie Junior College student, from behind a pile of old books at the Notre Dame School in Price on August 28, 1938. Piles of guano indicated that it had made its home there for some time. Additional material from this area may show that the subspecies *cantwelli* is found in the eastern part of the state. This specimen is placed here provisionally because of its grayer coloration and because of its smaller size when compared with the average of specimens from the western and southern parts of Utah.

Antrozous pallidus cantwelli Bailey

Records: None

Records (of *A. p. pacificus*): Miller (1897, p. 45) listed one specimen from "Saint Thomas, Utah" but this area, although once in the Territory of Utah, is now submerged beneath the waters of Mead Lake in southern Nevada. Presnall (1938, p. 6) reported specimens from Zion National Park in Washington County, Utah.

Specimens examined: MILLARD, Volcanic caves 10 mi. W Meadow, 10 (1 U); WASHINGTON, Zion Park, 3, Z; Saint George, 9.

Specimens from the southern and western part of Utah present a problem in classification because of their great variability. They are obviously intergrades between *pallidus* and *pacificus* but as Bailey (1936, p. 391) said in his description of *cantwelli* they "are not referable to either." Many of Bailey's characters seem not to hold true. Some individuals could be placed with *pallidus* while others could equally well be classified with *pacificus* but the differences between them are bridged both in size and color by other breeding individuals taken at the same time and place. The measurements of 20 are (extremes in parentheses): Total length, 109.5 (102–119); tail, 43.7 (37–50); foot, 12.4 (9–15); ear from notch, 29.9 (29–31); tragus, 16.3 (14–17); forearm, 53.7 (49.5–58). Skull: Basal length, 17.2 (16–18.2); zygomatic breadth, 12.1 (11.9–12.6); interorbital constriction, 4.3 (3.7–4.5). The length of bony palate behind molars (exclusive of median spine) was usually less than width at base of median spine, but this was not so in all cases. Bailey's character referring to small skull and light dentition seems to hold good.

There is considerable variation in color but the upper parts have a buffy tint lacking in the *pallidus* specimen from eastern Utah, although it is not as deep buffy as *pacificus* from Contra Costa County, California. The dark tips on the dorsal hairs seem to be grayer and not so brown as those of *pacificus*. The under parts vary from whitish to a pale buff but are not so pure white as that of the Carbon County specimen nor yet as deep buff as in California *pacificus*. It will be noted also that female specimens from Washington County average slightly larger than male specimens from the Fillmore region except for the skull, in which there seems to be no difference.

Of four pregnant specimens taken from beneath the casing of a house at Saint George on May 22, 1939, two contained one embryo each while the other two had two each. They seemed fully formed and about ready for birth.

A female taken from this same house on March 29, 1939, seems very close to *pallidus* and may have been a migrant, but another female taken April 6, 1939, is much larger and is referred to *cantwelli*. The bats from Millard County were taken from a large crack in the roof of a cave. They were near the entrance of the cave. All specimens in the cluster were males.

Tadarida mexicana (Saussure)

Records: Shamel (1931, p. 6): UINTAH, Jensen, 1; Woodbury (1933, p. 174): WASHINGTON, Zion National Park, observed; Presnall (1938, p. 7): WASHINGTON, Zion National Park, 1; Long (1940, p. 173): BEAVER, Beaver, colony; MILLARD, Fillmore, colony.

Specimens examined: TOOELE, cave at Salt Springs near Utah-Nevada State line, 4, Y; SALT LAKE, Salt Lake City, 1, U; JUAB, near Nephi, 1; CARBON, Price, 1; UTAH, Rock Canyon east of Provo, 1 Y; WASHINGTON, Saint George, 17 (1, Y).

In the southern part of Utah, these bats are very common. At Saint George each summer evening the air contains many of them. They seem to hibernate often in houses. Before recent repair work on the Education Building at Dixie Junior College, it was possible to use a hydrogen sulphide gas generator and by placing a rubber tubing beneath the exterior window casings, drive out these bats and thus capture them.

One immature bat was taken on a cool August morning as it hung on the side of a log granary near Nephi. One of 4 specimens in the Brigham Young University collection taken in June, 1928, at Salt Springs is a small hairless specimen attached to its mother.

Tadarida macrotis (Gray)

Records: Woodbury (1937, p. 515): WASHINGTON, Zion Park, 1; Durrant and Behle (1938, p. 500): WASHINGTON, Zion Park, 1.

Specimens examined: WASHINGTON, Saint George, 1.

The third specimen of this bat taken in Utah was obtained at Saint George by Dixie College students prior to May 1938. Unfortunately, no other data is available.

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Dixie Junior College, Saint George, Utah.

A STUDY OF THE HYOID APPARATUS OF THE CRICETINAE

By James M. Sprague

The hyoid apparatus of the Mammalia is a structure that has received little attention from anatomists and most of the literature on this subject deals with the larger mammals. With the exception of a few laboratory animals, the hyoid apparatus of the North American Rodentia is but little known. The purpose of this study is to describe the morphology of the hyoid of a rather generalized group of rodents, the American Cricetinae, and to ascertain the taxonomic significance of this structure within such a group. This paper deals with the following genera: *Onychomys*, *Reithrodontomys*, *Baiomys*, *Peromyscus*, *Oryzomys*, *Sigmodon*, *Neotoma*, *Hodomys* and *Xenomys*.

Material available consisted of alcoholic specimens for dissection, and dermestid-cleaned skulls with the bony hyoids attached and in place. The ligamentous and cartilaginous parts of the hyoid were of course not present in the material cleaned by dermestids. All measurements were made with a micrometer reading to tenths of a millimeter. After they had been removed from the skulls the specimens were studied by means of a binocular microscope and by the use of enlarged photographs showing the hyoids linearly arranged by species.

Alcoholic specimens were available in the following forms: *Onychomys leucogaster arcticeps*, *Reithrodontomys megalotis nigrescens*, *Peromyscus maniculatus bairdi*, *Oryzomys couesi couesi*, *Sigmodon hispidus texianus*, *Neotoma floridana osagensis*, and *Hodomys alleni*.

Skulls with attached hyoids were available in the following species: *Onychomys leucogaster* (*O. l. arcticeps, melanophrys*), and *O. torridus torridus; Reithrodontomys albescens albescens, R. megalotis dychei; Baiomys taylori subater; Peromyscus californicus insignis, P. eremicus eremicus, P. maniculatus* (*P. m. rufinus, nebrascensis, bairdi, pallescens, sonoriensis, ozarkium*), *P. leucopus* (*P. l. noveboracensis, aridulus*), *P. pectoralis laceianus, P. truei* (*P. t. truei, gilberti*), and *P. nuttalli areolus; Oryzomys palustris texensis; Sigmodon hispidus texianus; Neotoma floridana* (*N. f. osagensis, attwateri*), *N. micropus* (*N. m. micropus, canescens*), *N. albigula albigula, N. mexicana fallax*, and *N. lepida monstrabilis; Hodomys alleni;* and *Xenomys nelsoni*.

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Philadelphia Academy of Science for the loan of an alcoholic specimen of *Neotoma*; and to Dr. A. B. Leonard, Department of Zoology, University of Kansas, for technical assistance.

GENERAL CONSIDERATIONS

Tullberg (1899), working with the Rodentia, and Pocock (1916), with the Felidae, have recognized taxonomically significant characters of the hyoid apparatus. Tullberg did not attempt a comparison of the hyoid of the various genera and species within a group, but annotated the general characters of the structure of the entire group.

Owen (1835) was the first to point out a functional relationship between the structure of the hyoid apparatus and the voice of the lion (*Felis leo*). Pocock (1916) later supplemented this observation with a most interesting and similar correlation in many other species of the Felidae. He found that in the roaring cats (lion, tiger, leopard, jaguar and ounce) the anterior cornua of the hyoid were ligamentous and allowed the larynx and tongue considerable freedom of movement. In all of the remaining cats, which purr but never roar, the anterior cornua were completely bony, and consequently restricted the movement of the hyoid apparatus. Pocock used these characters of the hyoid to distinguish two of the three subfamilies of the Felidae. Perhaps he ascribed too much importance to a single structure, but his findings are significant nevertheless.

Allen, Lang, and Chapin (1917) have indicated a correlation between the size of the hyoid and larynx and the range of the voice in the Pteropidae (*Hypsignathus monstrosus*). Dobson (1881) has observed an interesting relationship between the structure of the hyoid and the food habits of *Epomops franqueti*, and the writer has found similar conditions existing in the long-tongued bats (Macroglossinae).

The above references indicate a frequent and dynamic relationship between the structure of the hyoid apparatus, and the vocal powers and the feeding habits in some of the Mammalia. Such a correlation was not possible in the group treated in this paper, but the rodents present an interesting possibility.

Howes (1896) has discussed several trends of development of the mammalian hyoid. The hyoid apparatus of mammals is derived from two visceral arches, the second and the third. Most of the basihyal and the entire anterior cornua are derived from the second visceral or hyoid arch; the remainder of the basihyal and the posterior cornua are from the third visceral arch. Each anterior cornu is embryonically a solid bar of cartilage, from which, in some mammals, four segments eventually become distinct and later ossify. To such a completely segmented condition Howes has given the name *integro-cornuate*. In other mammals, one or more of these segments is suppressed with the substitution of a ligament. Howes has called the ligamentous type of hyoid, *discreto-cornuate*. In some groups the reduction of the anterior cornua

has gone further, and the ligament itself has disappeared leaving the hyoid with no connection with the cranium.

The primitive position of the attachment of the anterior cornua to the skull is anterior to the stylomastoid foramen. Such a position has undergone in some mammals a gradual shift posteriorly, until the attachment is posterior to the stylomastoid foramen. Howes has termed the former condition *protrematic*, and the latter *opisthotrematic*.

The writer is using the terminology followed by van Kampen (1905), Kingsley (1925), Weber (1928), Goodrich (1930) and De Beer (1937), in naming the elements of the anterior cornu, from basihyal to cranium, hypohyal (ceratohyal), ceratohyal (epihyal), stylohyal and tympanohyal. The multiplicity of terms for these segments has led to confusion. Human anatomists and older authors have frequently used the terms in parenthesis to designate the two segments nearest the basihyal. The writer, however, agrees with the authors quoted above that the first mentioned terms are more in keeping with those commonly utilized to indicate the branchial arch segments of fishes, whether or not the latter prove to be homologous with their namesakes in mammals.

Howes had the following general statement to make regarding the hyoid apparatus of the Rodentia: "The close approximation of the paroccipital and mastoid process and the expansion of the extremity of the former, occurs in such genera as *Arvicola*, *Cricetomys*, *Fiber*, *Hydromys*, *Microtus*, *Neostoma* [*Neotoma*], and in several Muridae, and thus suggest a wide realization of the opisthotrematic condition for the rodent order. . . . and one is tempted to inquire whether, in respect to the anterior cornu of the hyoid, the enormous order Rodentia may not exhaust the conditions occurring throughout the class Mammalia." The writer has found in the Cricetinae that the anterior cornua do not enter into any relationship with the paroccipital processes, but are attached to the cranium medial to the posteroventral aspect of the ectotympanic portion of the bullae. This point of attachment is near the ventral expansion of the mastoid process, and it may well be that the latter process forms the connection between the hyoid and the cranium in other, allied groups of rodents.

Tullberg (1899) in his extensive phylogenetic study of rodent anatomy, recognized the family Hesperomyidae, in which were included *Hesperomys*, [*Peromyscus*] *leucopus*, *Neotoma floridana*, *N. cinerea*, and *Sigmodon hispidus*. Tullberg placed the Hesperomyidae, which is equivalent to the subfamily Cricetinae, in the Muriformes. He ascribed to the latter group the following characters of the hyoid: anterior horns generally singly segmented and small, often rudimentary; posterior horns with anteriorly projecting, pointed processes; posterior horns not fastened to the thyroid cartilage, but in general firmly connected with the corpus. A small and rather poor illustration of the hyoid of *Peromyscus leucopus* was included.

The general morphology of the hyoid apparatus of the Cricetinae as ascertained in this study may be described as follows (Fig. 1). The basihyal is a bar-shaped structure, the broad diameter of which greatly exceeds the rostrocaudal length. It is always more or less compressed, the compression

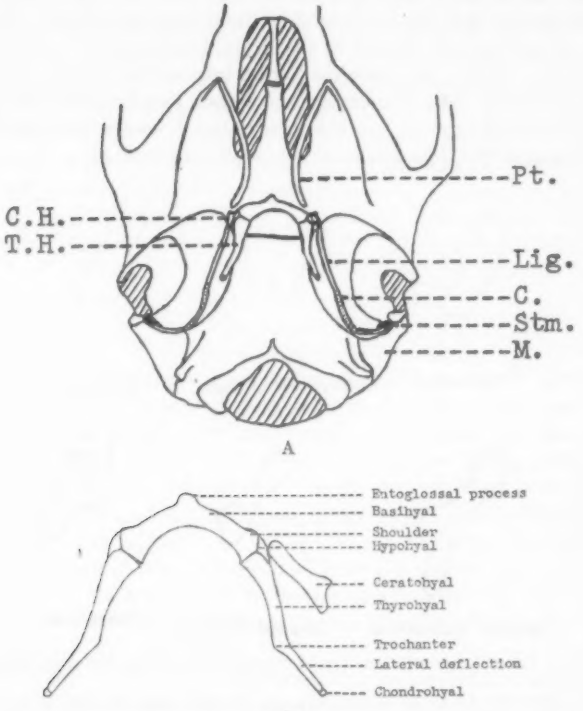

FIG. 1. A. Ventral view of the skull of *Neotoma micropus*, showing the hyoid apparatus. C, cartilage; C. H., ceratohyal; Lig., ligament; M., mastoid process; Pt., pterygoid process; Stm., stylomastoid foramen; T. H., thyrohyal. The ceratohyals extend dorsally from the basihyal and are thus barely discernible from the ventral view.

B. Ventral view of the hyoid of *Neotoma floridana*, with the ceratohyal pulled out laterally.

ranging from a plane parallel to the cranial axis (*Peromyscus*), to one almost at right angles to this (*Sigmodon*). The entoglossal process is usually well developed, but it may be absent (*Baiomys*, *Oryzomys*, *Sigmodon*). There are usually pronounced "shoulders," or anteriorly projecting processes, just anterior to the articulation with the thyrohyals (not on the thyrohyals as

stated by Tullberg). The posterior surface of the basihyal is concave; the anterior surface may be convex or it may be flat. The basihyal, thyrohyals and ceratohyals exhibit large marrow cavities, larger in young animals than in adults.

The thyrohyals are usually long and pointed, with the distal third exhibiting an outward flare or deflection lateral to the thyroid cartilage. The basihyal and the thyrohyals are bound to the thyroid cartilage by a broad sheet of fascia and by muscle; the thyrohyals enter into no direct connection with the thyroid cartilage. The thyrohyals are rather loosely articulated with the basihyal in young animals, but this articulation becomes quite firm in adults. The free ends of the thyrohyals exhibit small chondrohyals.

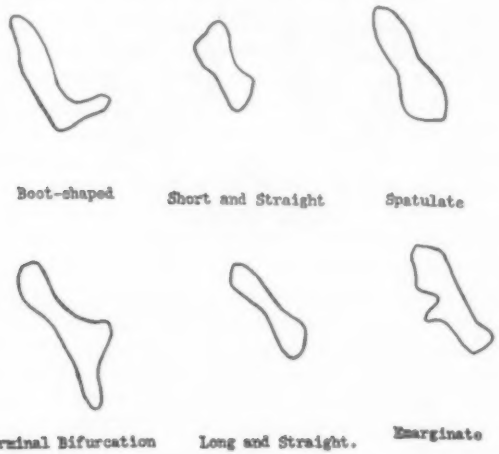

FIG. 2. Lateral view of a number of ceratohyals to show variation in shape

In the adult the bony elements are apparently two in each anterior cornu: (1) a minute, triangular, or in some cases flattened bone wedged into the lateral aspect of the basihyal-thyrohyal articulation, and (2) a more distal, blade-like element, variable in shape (Fig. 2), which extends dorsally, almost touching the presphenoid. These would seem to represent the hypohyal and the ceratohyal respectively.

From the free end of each ceratohyal in the genera *Onychomys*, *Reithrodontomys*, *Peromyscus* and *Neotoma*, a long and slender ligament extends posteriorly embedded in muscle to pass into the stylomastoid foramen in company with the facial nerve. As the ligament approaches the stylomastoid foramen it is held in place by fascia that originates from the posterior lip of the ectotympanic and the ventral surface of the mastoid process. Near the cranial end of the ligament, in all of the above mentioned genera except

Onychomys, lies a styliform piece of cartilage; in *Onychomys* this cartilage has become calcified. The identity of this element is not clear from the adult condition, and unfortunately a sufficient series of immature specimens was not available to settle this interesting question. Since, however, both hypohyals and ceratohyals are ossified, it seems possible that the cartilage represents the stylohyal and that the tympanohyal is entirely covered by the bulla and the mastoid process, perhaps being fused to the latter. As the ligament passed into the foramen and out of sight, and since no recognizable tympanohyal is evident, it is not possible at this time to say whether the attachment of the hyoid apparatus to the skull is protrematic or opisthotrematic. No ligament was evident in *Oryzomys*, *Sigmodon* and *Hodomys;* dissection specimens of *Baiomys* and *Xenomys* were not available.

Thus the anterior cornua of the Cricetinae are incompletely ossified and partially ligamentous (discreto-cornuate). The hypohyals in adult specimens of *Neotoma*, *Hodomys* and *Xenomys* are firmly wedged into the basihyal-thyrohyal articulation; in young specimens this element is loose and is easily lost in cleaning. In the remaining genera examined the hypohyals are flat, and are appressed against the lateral aspects of the basihyal. The ceratohyals in all of the genera studied are loosely articulated with the hypohyals in such a manner as to suggest a synovial cavity, although this has not been demonstrated. This ceratohyal-hypohyal articulation, together with the presence of the ligament extending between the ceratohyals and the cranium, makes possible considerable range of movement in the anterior cornu of the hyoid.

A slight sexual dimorphism with respect to the size of the hyoid has been noted in certain genera, but it is usually lacking. The hyoids of immature specimens are incompletely developed. They are smaller and less massive than in the adult, have a more extensive marrow cavity, and are lacking in bony processes. Individual variation is marked, and after maturity variation occurs without regard to age or sex.

The ossification centers in the hyoid apparatus of the Cricetinae were not determined, nor was the time at which ossification takes place. By the use of very young specimens cleared in potassium hydroxide and stained with alizarin red, it was found that the basihyal ossifies first, and that both the thyrohyals and ceratohyals ossify a short time later.

Because of individual variation, it should be emphasized that in those species of which only one specimen was available, the description recorded cannot be considered as inflexible. The author finds, however, after examining several hundred hyoids of the Cricetinae, that distinctive characters of this structure are characteristic of almost all of the species of the group. In closely related forms, such as *Peromyscus maniculatus* and *P. leucopus* a series is desirable in order fully to appreciate the differences. If only a few specimens of each species were available, characters that might seem diagnostic would represent only the extremes of variation that overlap within the

two. The genera on the other hand, exhibit wide differences in the characters of the hyoid. The sole exception was found in the occasional, close similarity between *Onychomys torridus*, and *Peromyscus maniculatus* and *P. leucopus*. The hyoid of *Onychomys leucogaster* is easily distinguished from that of *Peromyscus* by its size alone.

All drawings and measurements are of adult specimens, the measurements being in millimeters.

In the following discussion six measurements have been utilized. 1) Width of basihyal (B. H.)—measured from one lateral aspect to the other along the dorsal surface; 2) length of thyrohyal (T. H.)—the longer thyrohyal measured from its articulation with the basihyal to its free or thyroid extremity; 3) length of ceratohyal (C. H.)—the longer ceratohyal measured from its articulation with the hypohyal to its free extremity; 4) arch of the basi- and thyrohyals (Arch)—measured from the median posterior border of the basihyal to an imaginary line drawn across the free ends of the thyrohyals; 5) width of the thyrohyals (W. T. H.)—the distance between the free ends of the thyrohyals; 6) thickness of the basihyal through the entoglossal process (Ent.). This measurement was taken from the dorsal side with the basihyal lying flat, and thus if the entoglossal was bent sharply ventrally the actual length was not obtained. The fifth measurement (width of the thyrohyals) was found to be so variable that an average of this measurement has only limited significance.

Reference to Figs. 1 and 2 will illustrate the terms utilized in the following discussion. Distal and proximal are used with reference to the position of the part in question with the basihyal.

GENERIC SYNOPSIS

Onychomys is almost always separable from *Peromyscus* in the size of the hyoid, and this, together with the lack of arch of the basihyal and the slight development of the entoglossal process in the former will usually serve to distinguish the two. The ratio of length of the ceratohyal to the thyrohyal is greater in *Onychomys* than in *Peromyscus*. The hyoids of some specimens of *O. torridus* are, however, indistinguishable from those of *P. maniculatus* and *P. leucopus*.

The hyoid of *Reithrodontomys* is distinct from both *Onychomys* and *Peromyscus* in smaller size; otherwise it is similar to that of *Peromyscus*, especially *P. maniculatus*.

The hyoid of *Baiomys* is similar to that of *Reithrodontomys* in size. The basihyal is without an entoglossal process and is compressed anteroposteriorly. The thyrohyals are slight and the ceratohyals are similar to those of *Reithrodontomys albescens* in being larger proximally than distally. In the one specimen of *Baiomys* that I have available, the hyoid apparatus is smaller than in *Reithrodontomys* and less massive.

Peromyscus with its many species, of which I have seven, shows a wide range of variation in the hyoid and it is difficult to ascribe definite generic characters to this structure. The size alone of the hyoid will usually separate *Peromyscus* from any of the genera that were available to me. The size, plus the arched condition of the basihyal and the well developed entoglossal process are usually diagnostic. *P. californicus insignis* and *P. eremicus eremicus* are similar to *Onychomys* with respect to the shape of

the basihyal and thyrohyals. The characteristics of the ceratohyals, and the general size, however, will serve to distinguish them. The subspecies *P. maniculatus ozarkium* is distinct from other *maniculatus* that I examined with respect to the small size of the hyoid.

The hyoid of *Oryzomys* is somewhat similar to that of *Sigmodon* but is smaller and lacks the massiveness of the latter. The straight thyrohyals and the compressed basihyal lacking an entoglossal process in *Oryzomys* finds a strong similarity in *Peromyscus nuttalli arcolus*. The smaller size of the hyoid in the latter separates these two.

Sigmodon has the most distinctive hyoid of any genus of the Cricetinae that I have examined. The hyoid of adult specimens of *Sigmodon* is massive and is compressed anteroposteriorly; the basihyal arch is slight and no entoglossal process is evident. The thyrohyals are straight and are slightly expanded distally.

The hyoid of *Neotoma* is distinguished chiefly by its large size and the massiveness of the entoglossal process. The general shape is similar to the condition in *Peromyscus*, being much closer to the latter genus than is *Sigmodon*. *Neotoma* exhibits a massive basihyal with well developed shoulders. The thyrohyals have prominent lateral flares and median trochanters in *N. floridana* and *micropus*, lacking in *albigula*, *mexicana*, and *lepida*. The ceratohyals are variable in shape.

The hyoid in *Hodomys* is somewhat similar to that in *Neotoma*, but is distinct in the lack of shoulders, the pronounced arch of the basihyal, and the great length of the entoglossal. The thyrohyals are straight.

Xenomys like *Hodomys* has no shoulders on the basihyal, and the latter is arched even more so than in *Hodomys*. The entoglossal exhibits a terminal expansion unique among the genera examined and it is bent ventrally at an angle of 80° from the axis of the basihyal.

DESCRIPTION OF SPECIES

Onychomys.—*Basihyal.*—Usually compressed anteroposteriorly, with little arch, giving a decided flat or squarish appearance as the entoglossal process is usually not pronounced; shoulders usually well developed. *Thyrohyals.*—Long and slender with the free ends exhibiting a decided lateral flare, usually being accompanied by trochanters medial to the angle of bend. *Anterior cornua.*—*Hypohyals* flattened, cap-like, and appressed against the lateral aspect of the basihyal; apparently ankylosed with the basihyal in old adults; *ceratohyals* long and slender; boot-shaped in adults, straight in immatures; ligament well developed, enclosing a styliform piece of calcified cartilage.

(1) *O. leucogaster: O. l. arcticeps* with entoglossal process more pronounced than in *O. torridus torridus;* in the only available specimen of *O. l. melanophrys* the anterior edge of the basihyal is quite flat, exhibiting no shoulders and no entoglossal process; the thyrohyals of *melanophrys* are distinct from those of *arcticeps*, having none of the lateral bend of the latter; also, they are not pointed in *melanophrys* but are blunt and rounded, and are expanded distally; in my series of *arcticeps* the ceratohyals are boot-shaped in the adult females, straight in the adult males; hypo- and ceratohyals are missing from the single specimen of *melanophrys*.

Measurements.—*O. l. arcticeps* (6 spec.): B. H., 4.2; T. H., 2.3; C. H., 1.7; Arch, 2.7; W. T. H., 6.1; Ent., 0.7. *O. l. melanophrys* (1 spec.): B. H., 3.4; T. H., 2.4; C. H.,—, Arch, 2.5; W. T. H., 6.1; Ent., 0.4.

(2) *O. torridus torridus:* Hyoid smaller than in *leucogaster;* basihyal generally more flattened than in *arcticeps*, due to lack of development of entoglossal; shoulders well developed; thyrohyals not so pointed as in *arcticeps;* terminal processes of the ceratohyals limited to the adults, ceratohyals being straight in the immatures.

Measurements (11 spec.).—B. H., 3.7; T. H., 2.0; C. H., 1.6; Arch, 2.3; W. T. H., 5.4; Ent., 0.5.

Reithrodontomys.—*Basihyal.*—Similar to that in *Onychomys*, but with more arch and with a more pronounced entoglossal process; compressed anteroposteriorly. *Thyrohyals.*—Short in *R. albescens*, free ends blunt and rounded; longer in *megalotis*, free ends pointed; both species with lateral flare, but more pronounced in *megalotis;* the latter also exhibiting medial trochanters that are absent in *albescens*. *R. albescens* resembles *Peromyscus* in shape of thyrohyals and in general structure, while *R. megalotis* is closer to *Onychomys leucogaster arcticeps* with respect to the thyrohyals. *Anterior cornua.*—*Hypohyals* as in *Onychomys; ceratohyals* similar to those of *Baiomys taylori*, being larger proximally than distally; ceratohyals present in only one of three specimens of *R. megalotis;* here they are short and rectangular, resembling those of *Peromyscus cali-*

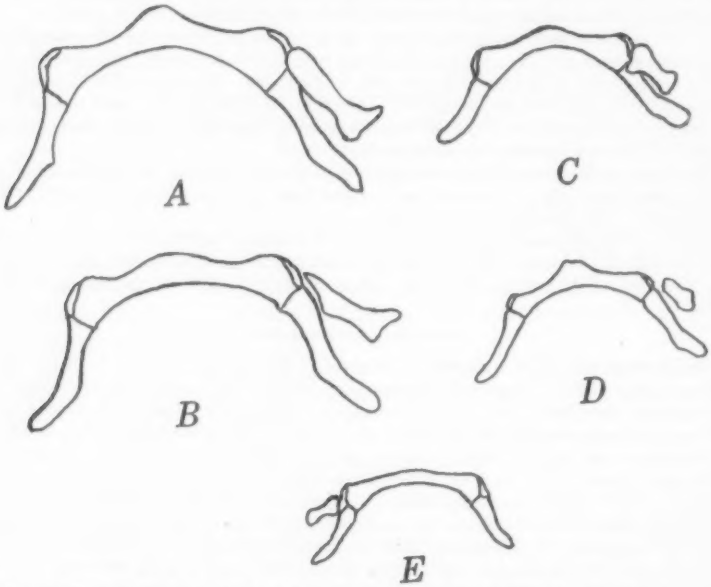

FIG. 3. Dorsal view of the hyoid apparatus of A. *Onychomys leucogaster arcticeps* (× 10); B. *O. torridus torridus* (× 10); C. *Reithrodontomys albescens albescens* (× 10); D. *R. megalotis dychei* (× 10); E. *Baiomys taylori subater* (× 10).

fornicus insignis; ligament present, enclosing a well developed piece of cartilage; anterior portion of ligament connecting ceratohyal with the cartilage is minute.

Measurements.—*R. albescens albescens* (1 spec.): B. H., 2.6; T. H., 1.5; C. H., 1.0; Arch, 1.7; W. T. H., 4.3; Ent., 0.4. *R. megalotis dychei* (3 spec.): B. H., 2.7; T. H., 1.5; C. H., 0.7; Arch, 1.7; W. T. H., 4.3; Ent., 0.6.

Baiomys.—*Baiomys taylori subater:* Basihyal without an entoglossal process, and compressed anteroposteriorly; thyrohyals slight, straight and pointed; ceratohyals similar to those of *Reithrodontomys albescens;* hypohyals as in *Reithrodontomys;* in the one specimen of *Baiomys* available, the whole hyoid apparatus is smaller and less massive than in *Reithrodontomys.*

Measurements (1 spec.).—B. H., 2.2; T. H., 1.4; C. H., 0.7; Arch, 1.4; W. T. H., 3.6.

Peromyscus.—The hyoid is similar to that of *Reithrodontomys*, but larger. *Basihyal.*—Usually compressed dorsoventrally; usually well arched and generally with a well developed entoglossal process, and shoulders; the squarish appearance of *Onychomys* is lacking. *Thyrohyals.*—Free ends usually blunt and rounded, showing a decided outward bend with median trochanters. *Anterior cornua.*—*Hypohyals* as in *Onychomys*, fused with the basihyal in the adults; *ceratohyals* varying widely in shape, being straight, boot-shaped, spatulate or terminally bifurcated; usually thin and blade-like, but occasionally thick and rectangular; ligament as in *Reithrodontomys*.

(1) *P. californicus insignis:* Entoglossal process only slightly developed; anterior border of basihyal flat without shoulders; arch of basihyal rather flat; thyrohyals with slight lateral flares and medial trochanters; ceratohyals short and rectangular without terminal processes. This is the only species of *Peromyscus* examined with ceratohyals of this character; it resembles *Reithrodontomys megalotis* in this respect.

Measurements (1 spec.).—B. H., 3.6; T. H., 2.4; C. H., 1.0; Arch,—; W. T. H.,—; Ent., 0.5.

(2) *P. eremicus eremicus:* Basihyal flattened, little arched and resembling that of *Onychomys leucogaster arcticeps;* entoglossal process not well developed; shoulders prominent; thyrohyals with prominent flares and slightly developed trochanters; ceratohyals well developed and spatulate.

Measurements (2 spec.).—B. H., 3.1; T. H., 2.1; C. H., 1.4; Arch, 2.0; W. T. H., 5.3; Ent., 0.6.

(3) *P. maniculatus:* Entoglossal process poorly to very well developed; basihyal arch slight to strongly developed; ceratohyals straight, boot-shaped, spatulate, or terminally bifurcated; thyrohyals usually exhibiting a moderate flare, but some without this feature; many with thyrohyals expanded slightly distally, many without; in several specimens the thyrohyal of one side noticeably larger than that of the other; thyrohyals usually with a small medial trochanter, in some pronounced, and in some not.

Some subspecific differentiation based on the hyoid is possible in *P. maniculatus*. *P. m. rufinus* averages larger than *nebrascensis* and *bairdi*, the latter two being about the same; *P. m. ozarkium* has much the smallest hyoid apparatus of any subspecies of *maniculatus* examined. The boot-shaped ceratohyal is the most common shape found in *rufinus* and *nebrascensis;* *nebrascensis* exhibits no bifurcated ceratohyals, however, and only rarely spatulate ones; in *rufinus* both of these latter shapes are commonly found.

A slight sexual dimorphism favoring the males with respect to size of the hyoid of *rufinus* and *nebrascensis* was found to be present. Generally speaking, however, it may be said that in *Peromyscus*, the variation of all elements of the hyoid occurs without regard to age or sex.

Measurements.—*P. m. rufinus* (16 spec.): B. H., 3.4; T. H., 1.9; C. H., 1.2; Arch, 2.1; W. T. H., 5.4; Ent., 0.6. *P. m. nebrascensis* (22 spec.): B. H., 3.2; T. H., 1.9; C. H., 1.2; Arch, 2.2; W. T. H., 5.2; Ent., 0.7. *P. m. bairdi* (10 spec.): B. H., 3.2; T. H., 1.9; C. H., 1.2; Arch, 2.1; W. T. H., 5.2; Ent., 0.6. *P. m. pallescens* (1 spec.): B. H., 3.2; T. H., 2.0; C. H., 1.4; Arch, 2.2; W. T. H., 5.5; Ent., 0.6. *P. m. sonoriensis* (1 spec.): B. H., 3.4; T. H., 2.4; C. H., 1.2; Arch, 2.8; W. T. H., 5.6; Ent., 0.6. *P. m. ozarkium* (2 spec.): B. H., 3.0; T. H., 1.6; C. H., 1.1; Arch, 2.0; W. T. H., 4.3; Ent., 0.5.

(4) *P. leucopus:* Hyoid slightly larger than in *maniculatus*, most noticeable in the lesser horns and entoglossal process; the hyoid generally more massive than in *maniculatus*, although the difference is not so apparent in measurements; variation of ceratohyals much as in *maniculatus* with the exception that the prominent boot-shaped ceratohyal found so commonly in the latter species is replaced by the spatulate in *leucopus;* only a few of the ceratohyals in *leucopus* are straight or terminally bifurcated; the thyro-

hyals vary as in *maniculatus*, more, however, are without or with only a slight distal expansion; a few show pronounced expansion.

Measurements.—*P. l. noveboracensis* (27 spec.): B. H., 3.4; T. H., 2.0; C. H., 1.3; Arch, 2.2; W. T. H., 5.6; Ent., 0.6. *P. l. aridulus* (19 spec.): B. H., 3.3; T. H., 2.0; C. H., 1.4; Arch, 2.2; W. T. H., 5.6; Ent., 0.6.

(5) *P. pectoralis laceianus:* Ceratohyals relatively shorter than in *leucopus*, exhibiting a posterior emargination not found elsewhere in my representatives of the genus, most marked in the old adults but evident also in the immatures; thyrohyals pointed and slender, with a decided flare and not exhibiting the bluntness found in many of the *maniculatus* and *leucopus* series; basihyal slightly more sloping, and with less pronounced shoulders than in *leucopus;* thyrohyals with or without trochanters.

Measurements (8 spec.).—B. H., 3.3; T. H., 1.9; C. H., 1.1; Arch, 2.1; W. T. H., 5.5; Ent., 0.6.

(6) *P. truei:* Thyrohyals with free ends blunt or pointed, with well developed flares and trochanters; ceratohyals lacking prominent distal processes, being straight or slightly spatulate; basihyal with more pronounced shoulders than in *pectoralis* but less so than in *leucopus*, or *maniculatus*.

Measurements.—*P. t. truei* (5 spec.): B. H., 3.6; T. H., 2.0; C. H., 1.3; Arch, 2.2; W. T. H., 5.7; Ent., 0.7. *P. t. gilberti* (1 spec.): B. H., 3.8; T. H., 2.2; C. H., 1.4; Arch, 2.4; W. T. H., 6.0; Ent., 0.8.

(7) *P. nuttalli aureolus:* Basihyal compressed antero-posteriorly as in *Oryzomys;* thyrohyals straight, slender, with a slight terminal expansion, a shape not found elsewhere in the genus *Peromyscus*, but resembling *Oryzomys;* basihyal similar to that of *Oryzomys*, the massiveness of the shoulders, found without exception in other species of *Peromyscus*, being entirely lacking in *P. nuttalli;* entoglossal process slightly developed; hypohyals and ceratohyals lost in cleaning.

Measurements (1 spec.).—B. H., 3.0; T. H., 2.2; C. H.,—; Arch, 2.4; W. T. H., 5.6; Ent., 0.6.

Oryzomys.—*O. palustris texensis:* Basihyal compressed anteroposteriorly as in *Peromyscus nuttalli* and *Sigmodon hispidus;* no entoglossal process; thyrohyals straight without terminal processes; ceratohyals and hypohyals missing in this specimen.

Measurements (1 spec.).—B. H., 3.8; T. H., 2.4; C. H.,—, Arch, 2.5; W. T. H., 6.4.

Sigmodon.—*S. hispidus texianus:* Basihyals with a decidedly squarish effect, massive shoulders, and a slight, or no, entoglossal process; basihyal compressed in an anteroposterior plane, and with a facet for the articulation of the ceratohyals; thyrohyals long and straight, expanded distally, and with no lateral flares or medial trochanters; ceratohyals long and straight, slightly emarginate in the adults; hypohyals small and round, apparently fused to the basihyal in the adult (the hypohyals of *Onychomys*, *Reithrodontomys*, *Baiomys* and *Peromyscus* are flat but rectangular in shape); no ligament was found.

Measurements (4 spec.).—B. H., 4.7; T. H., 3.3; C. H., 2.7; Arch, 3.6; W. T. H., 7.6.

Neotoma.—*Basihyal.*—With well-developed shoulders and massive entoglossal process; well arched but not compressed. *Thyrohyals.*—With prominent distal flare and trochanters in some species, some without; pointed or blunt. *Anterior cornua.*—*Hypohyals* usually triangular and wedged into the lateral aspect of the basihyal-thyrohyal articulation; in some species slightly flattened; *ceratohyals* varying from straight, boot-shaped, spatulate, bifurcated distally, to emarginate; strongly developed ligament, enclosing a long piece of cartilage.

(1) *N. floridana:* Basihyal with prominent entoglossal process and shoulders; basihyal arch well developed; thyrohyals without exception are long and pointed, with prominent lateral flares and medial trochanters; hypohyals triangular and not fused with the basihyal even in old adults; ceratohyals variable, long and straight, short and straight, bifurcated distally or emarginate.

Measurements.—*N. f. osagensis* (10 spec.): B. H., 6.8; T. H., 5.3; C. H., 2.6; Arch, 5.5; W. T. H., 11.0; Ent., 1.6. *N. f. attwateri* (1 spec.): B. H., 6.8; T. H, 5.3; C. H.,—; Arch, 5.9; W. T. H., 10.6; Ent., 1.9.

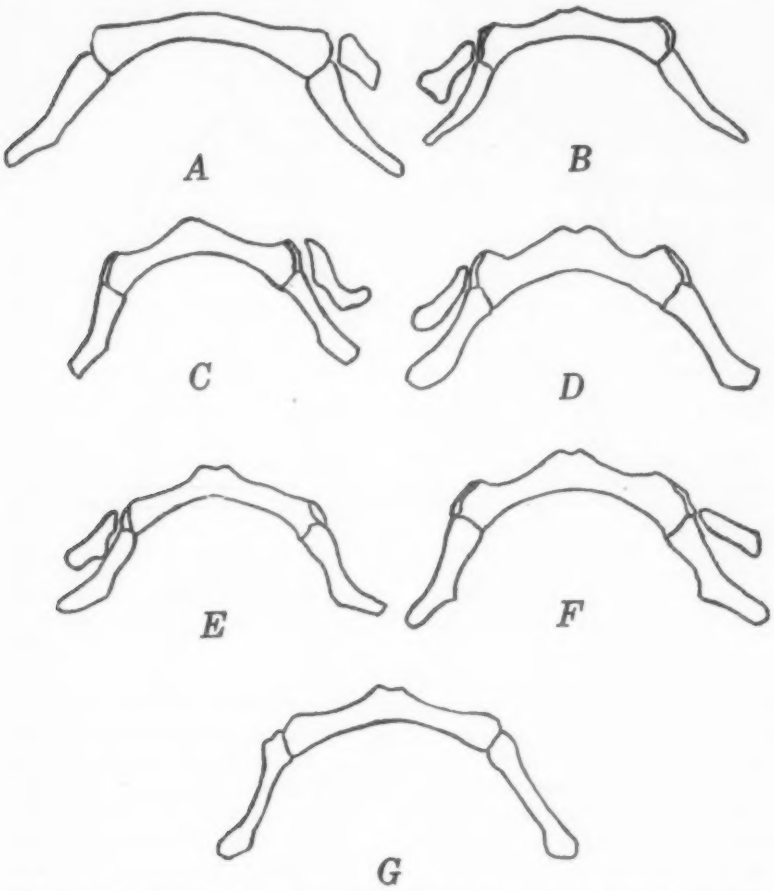

FIG. 4. Dorsal view of the hyoid apparatus of A. *Peromyscus californicus insignis* (× 10); B. *P. eremicus eremicus* (× 10); C. *P. maniculatus rufinus* (× 10); D. *P. leucopus noveboracensis* (× 10); E. *P. pectoralis laceianus* (× 10); F. *P. truei truei* (× 10); G. *P. nuttalli aureolus* (× 10).

(2) *N. micropus:* Hyoid similar to that of *floridana* but shoulders more pronounced and hypohyals slightly more flattened; hypohyals fused to the basihyal in old adults; ceratohyals variable in shape.

Measurements.—*N. m. micropus* (2 spec.): B. H., 7.5; T. H., 5.5; C. H., 2.6; Arch,

5.9; W. T. H., 11.4; Ent., 1.9. *N. m. canescens* (1 spec.): B. H., 7.2; T. H., 5.0; C. H., 3.0; Arch, 5.0; W. T. H., 11.6; Ent., 2.2.

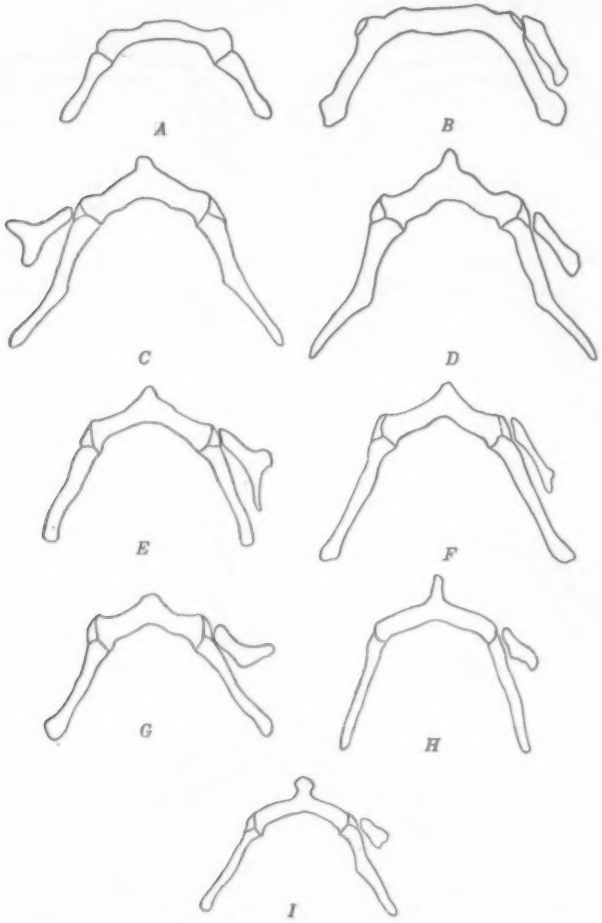

FIG. 5. Dorsal view of the hyoid apparatus of A. *Oryzomys palustris texensis* (× 2¼); B. *Sigmodon hispidus texianus* (× 2¼); C. *Neotoma floridana osagensis* (× 1¾); D. *N. micropus micropus* (× 1¾); E. *N. albigula albigula* (× 1¾); F. *N. mexicana fallax* (× 1¾); G. *N. lepida monstrabilis* (× 1¾); H. *Hodomys alleni* (× 1¾); I. *Xenomys nelsoni* (× 1¾).

(3) *N. albigula:* Hyoid smaller than in *floridana* and *micropus;* thyrohyals straight, lacking distal flare and medial trochanters; ceratohyals variable; hypohyals triangular as in *floridana.*

Measurements.—*N. a. albigula* (2 spec.): B. H., 6.2; T. H., 4.0; C. H., 2.4; Arch, 4.4; W. T. H., 9.2; Ent., 1.3.

(4) *N. mexicana:* Size of hyoid as in *albigula;* ceratohyals long, slender and slightly bifurcated distally; hypohyals as in *albigula;* thyrohyals straight, longer than in *albigula;* shoulders well developed.

Measurements.—*N. m. fallax* (1 spec.): B. H., 6.2; T. H., 5.0; C. H., 3.0; Arch, 5.4; W. T. H.,—; Ent., 1.4.

(5) *N. lepida:* Basihyal rather small; thyrohyals straight and slender with no terminal processes, no flare and no trochanters; ceratohyals boot-shaped, *lepida* being the only species of my representatives of *Neotoma* to exhibit this condition, although more specimens may show the ceratohyals to be variable in shape; hypohyals triangular, as in *albigula.*

Measurements.—*N. l. monstrabilis* (1 spec.): B. H., 5.2; T. H., 4.4; C. H., 2.2; Arch, 4.4; W. T. H., 9.8; Ent., 1.3.

Hodomys.—*Hodomys alleni:* Basihyal with very long, pointed entoglossal process; basihyal lacking massiveness of *Neotoma;* strongly arched, with no shoulders; flattened in a dorso-ventral plane, and showing no tendency toward the antero-posterior plane as does *Neotoma.* Thyrohyals long, straight and pointed, with no lateral flare or trochanters. Hypohyals missing in this specimen, but probably triangular as are those of both *Neotoma* and *Xenomys;* position of hypohyals as in *Neotoma;* ceratohyals short and slightly emarginate posteriorly. No ligament is present between the ceratohyals and the cranium.

Measurements (1 spec.).—B. H., 6.7; T. H., 4.9; C. H., 2.1; Arch, 6.0; W. T. H., 10.1; Ent., 2.4.

Xenomys.—*Xenomys nelsoni:* Hyoid generally resembling that of *Hodomys,* smaller. Basihyal with entoglossal process well developed and bent ventrally 80° from the broad axis of the corpus; entoglossal with a terminal expansion, not found in any other genus examined; basihyal arched more strongly than even in *Hodomys;* no shoulders. Thyrohyals long, straight and pointed; slight trochanters near the middle of the median edge. Hypohyals as in *Neotoma micropus,* i.e., triangular, but slightly more flattened than in *N. floridana;* ceratohyals short, and slightly spatulate.

Measurements (1 spec.).—B. H., 5.1; T. H., 4.9; C. H., 1.6; Arch, 4.3; W. T. H., 10.3; Ent., 1.8.

CONCLUSIONS

Generic relationships of the Cricetinae as indicated by the characters of the hyoid apparatus are as follows. With respect to the shape of the basihyal and thyrohyals, *Onychomys leucogaster* and *O. torridus* are similar to *Peromyscus californicus* and *P. eremicus* (subgenus *Haplomylomys*). *Reithrodontomys albescens* and *R. megalotis* generally resemble *Peromyscus maniculatus* (subgenus *Peromyscus*), except in size. *R. albescens* is also similar to *Baiomys taylori* with respect to the shape of the ceratohyals, and *R. megalotis* is similar to *Peromyscus californicus* with reference to the same element. *Baiomys taylori* is somewhat unique in lacking an entoglossal process, present in *Onychomys, Reithrodontomys,* and *Peromyscus.* All of these four genera, *Onychomys, Reithrodontomys, Baiomys* and *Peromyscus,* have the same type of hypohyal.

The three subgenera of *Peromyscus* included in this study have distinctive hyoids. The subgenus *Haplomylomys* (*P. californicus* and *P. eremicus*) shows affinities with *Onychomys.* The subgenus *Peromyscus* (*P. maniculatus,*

leucopus, *pectoralis* and *truei*) shows relationships with *Reithrodontomys*. The subgenus *Ochrotomys* (*P. nuttalli*) is similar to *Oryzomys palustris*.

The hyoid of *Oryzomys palustris* shows a strong similarity to *Peromyscus nuttalli* on the one hand, and a slight resemblance to *Sigmodon hispidus* on the other. An entoglossal process is lacking in both *Oryzomys* and *Sigmodon* and also in *Baiomys*. In all the other genera it is present.

Sigmodon is, however, with respect to the hyoid, in no way similar to *Neotoma*, whose affinities are with *Peromyscus* (especially of the subgenus *Peromyscus*). Except for the differences in shape of the hypohyals and in general size, the hyoid apparatus of *Peromyscus* and *Neotoma* is much the same. That of *Sigmodon* is distinct from either, and on the basis of the hyoid structure *Sigmodon* should not be placed in the Cricetinae.

Hodomys and *Xenomys* resemble *Neotoma* with respect to the hyoid, but on the basis of this structure are distinct from the latter and from each other.

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Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

A REMARKABLE FAMILY OF RODENTS FROM KASAKHSTAN, U.S.S.R.

B. S. Bashanov and B. A. Belosludov

A new genus and species of rodents was described by the authors (1939) from the collections made in 1938 by V. A. Selevin and B. A. Belosludov on an expedition of the Central-Asian (Tashkent) and Kazakh (Alma-Ata, formerly Vernyi) State Universities to the Betpak-dala Desert. The new genus was names *Selevinia betpakdalaensis* in honor of the late V. A. Selevin, who died before the material was worked up.

Relying mainly upon the number of molars, the new genus was at first referred to the family Muridae, but upon further study the writers find it necessary to consider *Selevinia* as representing a distinct family

Seleviniidae *fam. nov.*

Diagnosis.—Small, mouse-like animals, with long tail. Skull of moderate size with rounded outlines, but rather elongated and with broad occipital region. Zygomatic arches weak, narrowly spreading (12.0 mm); bullae osseae very large, their length equal to about 45 per cent of the condylobasal length, their breadth about 56 per cent of their length. The parietal bones extend unusually far forward, with a corresponding reduction of the frontals; braincase fairly large, rostrum elongated, nasals coalesced and projecting noticeably forward.

Dental formula: $i\ \frac{1}{1}$, $c\ \frac{0}{0}$, $pm\ \frac{0}{0}$, $m\ \frac{3}{3}$

The upper incisors are massive, long, almost straight, and directed vertically downward and somewhat medially, with a deep, longitudinal groove on the anterolateral surface. Their cutting edges form an angle, the apex of which meets the groove, thus forming two indentations that create the impression of double incisors. As a whole they resemble the incisors of *Ochotona*. Lower incisors normal, smooth, and of small size. Judging from the drawing, the lower incisors of the animals investigated by Argyropulo and Vinogradov (1939), as compared with specimens available to the present writers, are stouter at the base, straighter, and relatively shorter. The cheek teeth are exceedingly small, brachydont, broadened above and with a narrow neck below, with a rounded, concave (cupshaped) and smooth masticatory surfaces. They are low, scarcely projecting above the gums; length of upper row 13.6 per cent of condylobasal length, that of the lower only 12 per cent; roots well developed, there being two small lateral branches and a single large one.

The fur is dense and rather long; ears large; manus with four digits, pes with five; palms and soles naked. Pelage (summer): Light gray dorsally, with a close fine speckling almost black in color. This effect is due to the color

of individual hairs. Their basal three-fourths are dark slaty, followed first by a narrow belt of a slightly paler gray and finally by an almost black tip. Boundary between dorsal and ventral aspects rather abrupt. Belly mouse-gray, washed with yellow; chin and parts around lips white; ears covered with reddish hair on outside, naked on inside at base, with pale gray hairs on upper part; vibrissae dark with white tips, or pure white; tail faintly bicolored, lighter below, without conspicuous scales, thinly covered with short, light-tipped hairs.

Remarks.—The new family is very peculiar. In the general appearance of the skull and, in particular, in the form of the auditory bullae it resembles the superfamily Myoxoidea, yet the structure of the teeth in the Myoxoidea,

TABLE 1.—*Measurements of Selevinia betpakdalaensis*

	NUMBER 1	NUMBER 2	NUMBER 3	NUMBER 4	NUMBER 5	AVERAGE
Greatest length of skull	—	—	21.5	21.8	22.1	21.8
Basal length	—	—	18.9	18.7	18.7	18.8
Condylo-basal length	—	—	20.8	20.1	20.4	20.4
Interorbital constriction	—	—	4.1	4.2	4.3	4.2
Zygomatic breadth	—	—	12.0	—	—	—
Length of bullae osseae	—	—	9.0	9.1	9.1	9.07
Breadth of bullae osseae	—	—	5.1	5.4	5.3	5.2
Length of nasals	—	—	7.4	7.2	7.0	7.2
Breadth of nasals	—	—	2.8	3.2	3.0	3.0
Length of rostrum	—	—	5.1	5.4	5.0	5.1
Skull height	—	—	9.5	9.7	9.8	9.6
Length of upper molar series	—	—	1.6	1.5	1.6	1.5
Length of lower molar series	—	—	1.6	1.8	1.7	1.7
Total length	82	78	95	75	87	83.4
Length of tail	77	70	72	58	67	68.8
Length of hind foot	16	16	17	16	16	16.2
Height of ear	17	14	18	17	17	16.6

namely, the flat masticatory surface covered with transverse ridges, differs wholly from the concave, smooth cup characteristic of the teeth of the Seleviniidea. The lack of specimens of extra-Palaearctic rodents prevents the authors from clearing up the genetical relationships of the family.

The family consists of a single genus *Selevinia* Bashanov and Belosludov, with the characters of the family, and of one species

Selevinia betpakdalaensis Bashanov and Belosludov

1939. *Selevinia betpakdalaensis* Bashanov and Belosludov, Sci. Rec. S. M. Kirov St. Univ., vol. 1, Biology, pp. 81–86. Alma-Ata (in Russ.), Feb. 5.

1939. *Selevinia paradoxa* Argyropulo and Vinogradov. Priroda (Nature), no. 1, pp. 81–83. Leningrad (in Russ.), March 17.

HABITS AND GEOGRAPHICAL DISTRIBUTION

Observations on the animal made by Selevin and Belosludov were very fragmentary. Betpak-dala is a vast desert, one of the most barren and

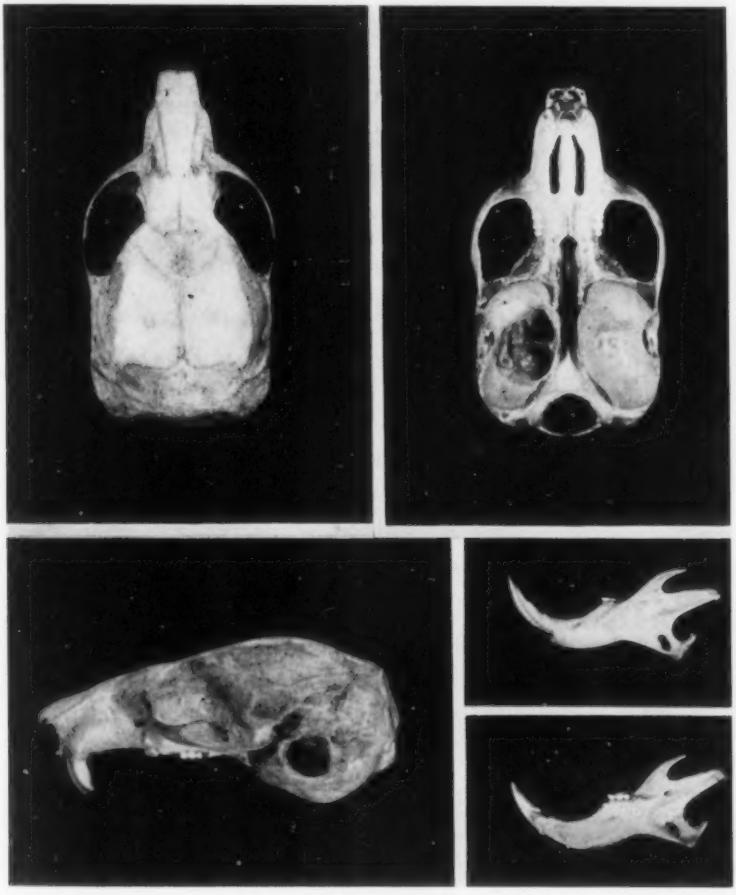

PLATE 1

Skull and lower jaws of *Selevinia betpakdalaensis* Bashanov and Belosludov, the type-genus on which the new family Seleviniidae is based.

sterile parts of Turkestan and Kazakhstan (Kirghiz steppes), lying west of Lake Balkhash and occupying the area between that lake and the rivers Chu on the south and the Sara-Su on the west. It is devoid of human population,

being a flat waterless plain with a thick, usually salty, soil overgrown with sparse wormwood and saltgrasses, which dry up at the beginning of summer. In some places groups of hills occur.

Selevinia was found in thin growths of a small desert bush (*Salsola laricifolia*) with an admixture of white wormwood (*Artemisia terrae-albae*) on rubble-clayey, brown, saliniferous soils. The animals were seen only before sundown; no definite burrows of the rodents were found. The observers believed that a deserted burrow detected near where the animal was pursued on July 31 belonged to one of them. It was a small vertical cul-de-sac with two horizontal short lateral holes (6–8 cm in diameter, 15 cm in length), wherein was found a small store of *Salsola laricifolia* leaves and wormwood shoots. As the remains of the same plants were present in the mouth cavities and in the stomachs of dissected animals, it is assumed that the stores kept in the burrow belonged to the rodent in question and that these plants constitute its principal food. It is noteworthy that the stomach contents were nearly unground, which seems to be due to the small size of the molars that apparently take almost no part in the chewing of the food.

Selevinia moves in small jumps on its hind legs. It has not been caught in traps; all specimens were captured by hand. The extreme limits of the new rodent's known range in 1938, namely, Kara-ungur and the vicinity of the Aibat hills, are situated 180–200 km apart. The animal appears to be rather rare, only five specimens were captured by the expedition. Although the animals investigated were neither secured nor observed during the last years of the work of the expedition, still they seem to be widely distributed in Betpak-dala. They were known to the guide of the expedition, a Kazakh by birth, who said that for them there existed even a Kazakh name (djalman-kulak and kalkan-kulak). According to his statement, the mice dwell all over the Betpak-dala Desert, perhaps southward as far as the lower part of the river Chu. This fact finds sufficient confirmation in the results of analyses of bird of prey pellets collected beyond Betpak-dala by Argyropulo and Vinogradov. Fragments of different parts of the skull belonging to the rodent considered were reported from the following points of Betpak-dala: in 1934—Chinguildy, in the western part of the desert near the river Sary-Su; in 1935—the wells Chekmen-Kalgan and Kyz-Kazgan on the Tas-bulak tract in the central part of the desert (the former at a distance of some 75 km from the river Chu), and the southeastern foot of the Baigar hills in the eastern part of the desert.

The range of the species, as pointed out above, covers a very extensive area wherein the ecological conditions are similar: associations of *Salsola laricifolia* and *Artemisia terrae-albae*. *Selevinia* lives together with *Ellobius talpinus*, *Allactaga jaculus vexillarius*, *Allactaga saltator suschkini*, and *Alactagulus acontion acontion*.

In conclusion, the writers wish to express their gratitude to Professor V. G. Heptner, Keeper of Mammals in the Zoological Museum of the University of Moscow, for his attention and valuable assistance given to their work.

Department of Vertebrate Zoology, Kazakh State University, Alma-Ata, U.S.S.R.

A MODIFIED TECHNIQUE IN THE PREPARATION OF MAMMAL SKINS

By E. J. Koestner

Notes and articles appear frequently in scientific journals presenting new techniques for preparing mammal study skins. Many of them have certain definite advantages and are often better for some specialized studies than the usual method. Unfortunately, however, in considering such presentations we are faced with the fact that mammal skins have been prepared by certain orthodox methods for many years, with the result that there are many thousands of skins in museums and collections throughout the world. All of them, having been prepared by the same method, are comparable. The disadvantages of such new methods are obvious. Thus, in consideration of these facts, if changes in skinning technique are proposed they must be limited to such changes that will give a finished skin comparable to others prepared by standard methods. The following description bears this in mind.

I have found, chiefly as the result of a dislike for sewing up mammal skins, that the same skin can be prepared without making any incision through the pelt and thus eliminating the necessity of sewing it. The result is not only a time-saver but gives a finished skin lacking stitches to mar the appearance of the under pelage. The chief difference in technique lies in the removal of the body of the specimen through the oral opening instead of through the customary abdominal incision. The following outlines the steps in the procedure.

1. Measure the specimen in the usual manner.
2. Open the mouth and make cuts separating the lip from the head. (Plate 1a)
3. Turn the skin back and proceed, thus turning the skin inside out. (Plate 1-b, c, d) (If the intestines contain a great deal of food some care must be used at this point. A little practice will enable this bulky portion to be put through the mouth-opening with ease.)
4. Cut off legs in the usual manner as they appear. (Plate 1d)
5. Remove tail.
6. Wrap cotton around leg bones and insert tail wire. (Plate 1e)
7. Attach body to tail wire and turn skin right side out over the cotton body. (Plate 1f)

8. Shape body and close mouth with one stitch.
9. Pin to dry in usual manner.

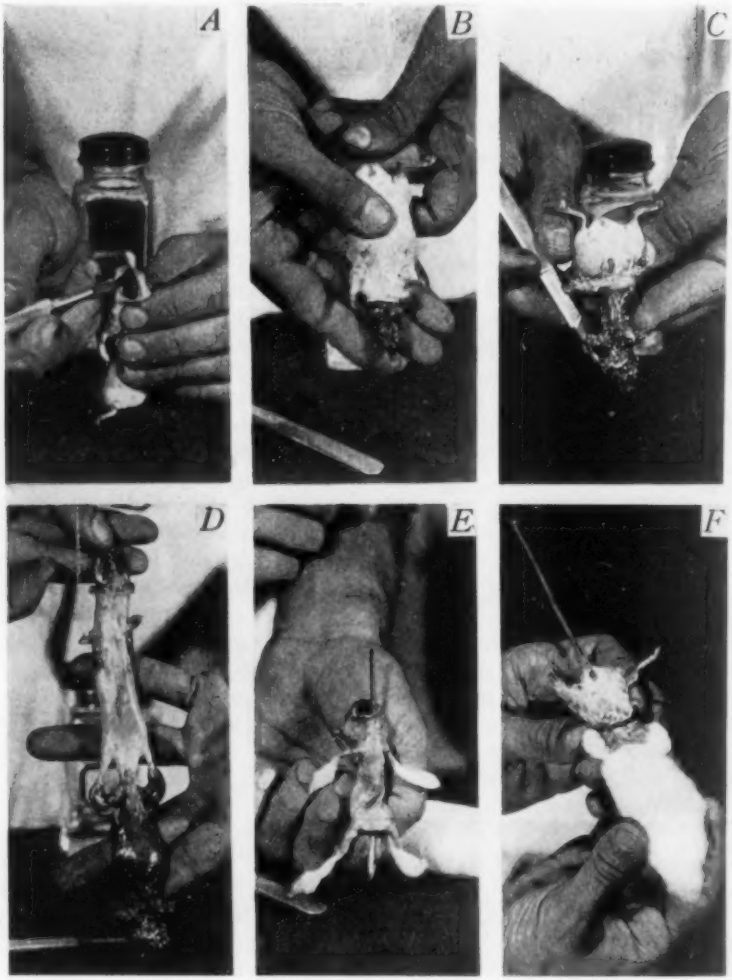

PLATE 1 (a, b, c, d, e, f). Steps in skinning a specimen of *Peromyscus*

It is most important that the cotton body be shaped to the proper size before being placed in the skin as removal or addition of cotton is difficult.

A good grade of long-fiber quilting cotton with some "spring" in it is likewise essential to the efficient execution of this method.

It is not claimed that this technique can be applied to all mammals prepared for study skins without some possible modifications. It has been used successfully on *Peromyscus, Mustela, Glaucomys, Pitymys,* and *Citellus* by the writer. An attempt on *Cryptotis* proved futile. No others have been tried.

Department of Zoology, University of Illinois, Champaign, Illinois.

A NEW SHREW (GENUS BLARINA) FROM TEXAS

By William B. Davis

The capture of an adult female shrew on the Aransas National Wildlife Refuge, Aransas County, by a CCC enrollee engaged in clearing a right-of-way through live-oak shinnery in a sandy area near the center of the Refuge revealed the unexpected presence of *Blarina brevicauda* on the coast of Texas, fully 250 miles to the south and west of the previously known localities in this state whence the genus has been reported. This specimen, presented to the Texas Cooperative Wildlife Collection by Refuge Manager James O. Stevenson, incited an attempt to capture additional specimens. In approximately 100 trap-nights another specimen, a subadult male, was captured in a live-oak grove near Dagger Point on the eastern side of the Refuge.

These two specimens are so much different from specimens of *Blarina b. carolinensis* (Bachman) examined from eastern Texas, Alabama, and South Carolina; from specimens of *B. b. talpoides* (Gapper) from Ohio; and from specimens of *B. b. hulophaga* Elliott from Oklahoma and Kansas that in my opinion they merit taxonomic recognition, and for them I propose the name:

Blarina brevicauda plumbea, new subspecies

Plumbeous Short-tailed Shrew

Type.—Female, adult; skin and skull; no. 1541, Texas Cooperative Wildlife Collection; one-half mile west of Marano Mill, Aransas National Wildlife Refuge, Aransas County, Texas; collected January 31, 1941, by James O. Stevenson, original no. X26 (X catalog T.C.W.C.). Paratype, no. 1542 (T.C.W.C.), subadult male; skin and broken skull, from Dagger Point, Aransas Refuge.

Diagnosis.—A small plumbeous-colored *Blarina* resembling *B. b. hulophaga*, but smaller and much paler; posterior border of palate highly arched anterodorsally; posterior projections of maxillae terminating on a plane with, or anterior to, the posterior edges of m^2. External measurements of type and paratype, respectively: 85, 92—16, 21.5—12, 12.5.

Comparisons.—Compared with *Blarina brevicauda hulophaga* (type and paratype, and three non-typical specimens from Hamilton, Kansas, available): Color plumbeous, rather than brownish, resulting from less brown producing pigment in the terminal portion of individual hairs; posterior border of palate highly arched anterodorsally, rather than straight or slightly arched; tail bicolored, darker above than below. Com-

pared with *B. b. carolinensis* (topotypes and near topotypes available): Plumbeous, rather than brownish; cranial measurements greater; pm^4 noticeably larger; posterior projection of maxilla terminating on a plane with or anterior to the posterior edge of m^2. Compared with *B. b. talpoides* from Ohio: Smaller and grayer. No specimens of *B. b. brevicauda* were available for comparison.

Remarks.—Aside from the occurrence of *Blarina* in Costa Rica, about which some controversy has arisen (see C. H. Merriam, N. Amer. Fauna, no. 10, p. 10, and J. A. Allen, Bull. Amer. Mus. Nat. Hist., vol. 9, no. 3, p. 34), the specimens from the Aransas Refuge extend the known range of *Blarina* several hundred miles to the south and west in the United States and constitute the southwesternmost record of capture of this genus.

TABLE 1.—*Cranial measurements (in millimeters) of specimens of three races of Blarina brevicauda*

GREATEST LENGTH OF SKULL	CRANIAL BREADTH	PALATAL LENGTH	POST-PALATAL LENGTH	INTER-ORBITAL BREADTH	MAXILLARY BREADTH ACROSS I^3	TOOTH ROW Pm^4-m^3	TOOTH ROW (FRONT OF INCISORS TO 4TH UNICUSPID)
Blarina b. carolinensis (10 specimens)							
19.5 (19.0–20.4)	10.3 (10.0–10.7)	8.9 (8.4– 9.4)	8.4 (7.9–8.9)	5.3 (5.2–5.6)	3.1 (3.0–3.2)	5.2 (5.0–5.4)	3.5 (3.1–3.8)
Blarina b. hulophaga (4 specimens)							
21.4 (21.3–21.5)	11.3 (11.2–11.5)	9.7 (9.2–10.0)	9.2 (9.0–9.3)	5.6 (5.4–5.7)	3.6 (3.4–3.7)	5.7 (5.5–5.9)	4.0 (3.6–4.2)
Blarina b. plumbea (2 specimens)							
21.2	11.0–11.1	9.5– 9.9	9.1	5.4–5.5	3.4–3.4	5.4–5.6	4.0–4.1

The two specimens of *plumbea* are unexpectedly more similar to *hulophaga* from Oklahoma than to *carolinensis* from the Big Thicket area of Texas. In fact, it seems likely that the population of this insectivore on the Aransas Refuge constitutes a relict of a previous larger population that extended southward from Oklahoma, as do the populations of the thirteen-lined ground squirrel (*Citellus tridecemlineatus texensis*) and the pine mouse (*Pitymys pinetorum auricularis*) today.

On the basis of cranial characters, *plumbea* and *carolinensis* might justifiably be considered as belonging to two separate species. The size of pm^4 and m^3 is noticeably smaller in all specimens of *carolinensis* examined and the palatal length in this race is actually and relatively shorter than in the series of races with which *plumbea* is most closely related.

Specimens examined.—Two, the type and paratype mentioned previously.

Department of Fish and Game, Agricultural and Mechanical College of Texas.

GENERAL NOTES

ADDITIONAL RECORDS OF NOTIOSOREX CRAWFORDI FROM TEXAS

The account of *Notiosorex crawfordi* by Fisher in this number of the Journal (pp. 263–269) prompts me to place on record five additional specimens of this shrew from Texas that have come to my attention. A specimen now preserved in formalin, was collected at Riviera, Kleberg County, in the lower Rio Grande plains, in 1940 and turned over to J. C. Cross, Texas College of Arts and Industries, Kingsville, Texas. According to Cross (*in litt.*) it was taken from an underground cellar where it was feeding on roaches. External measurements of this specimen are 85–26–10.5–7.0.

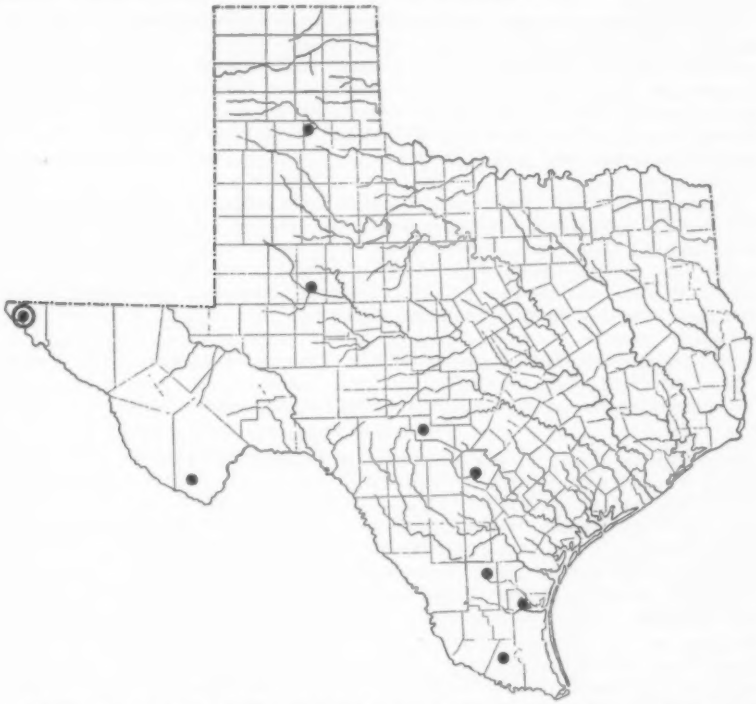

FIG. 1. Map showing the known distribution of *Notiosorex* in Texas. Solid circles indicate localities whence specimens have been recorded; solid circle within an open circle indicates the type locality.

The second specimen, skull only, was collected July 2, 1932, by M. F. Landwer, Texas Technological College, Lubbock, Texas, in Tula Canyon, Briscoe County, in the Panhandle of Texas. This specimen extends the known range of *Notiosorex* in Texas several hundred miles to the northward. Cranial measurements of this specimen are: Length of skull, 17.0; cranial breadth, 8.3; interorbital breadth, 3.9; palatal length, 7.5; maxillary breadth, 5.3; greatest length of mandible, 10.0.

The third specimen (alcoholic, in poor condition) was caught by a cat at Big Spring, Howard County, Texas, in 1928, buried, and later dug up by Lorraine Sears and given to Landwer. This specimen is now no. 80248, University of Michigan Museum of Zoology.

The fourth specimen, a female, skin and skull, was collected by W. H. Lacey, July 10, 1901, at the head of the Guadalupe River in the northern part of Kerr County and given to H. P. Attwater who, in turn, presented it to the American Museum of Natural History. No measurements were taken by the collector; the hind foot (dry) measures 10.2 mm. Cranial measurements of this specimen are: Length of skull, 16.9; cranial breadth, 7.9; interorbital breadth, 4.0; palatal length, 7.2; maxillary breadth, 4.9; greatest length of mandible, 9.9.

The fifth specimen, a female, skin and skull (skin only available to me), was collected August 2, 1939, by Kenneth E. Stager, two miles south of Faysville, Hidalgo County, and presented to the Los Angeles Museum. External measurements are 95-29-10.5-8.5. According to Stager (*in litt.*) three or four specimens of this shrew were found in the heart of wood rat nests (*Neotoma micropus*) that were torn apart by him and Dr. Sherwin S. Wood in search of cone-nosed bugs (*Triatoma*). Perhaps this information is the clue for which collectors who have tried in vain to capture this elusive shrew have been searching.

These additional specimens bring the known Texas specimens of *Notiosorex* to 12, from 9 different localities, as follows: *Briscoe County:* Tule Canyon, 1 (Mus. Zool.). *Howard County:* Big Spring, 1 (mus. zool.). *Kerr County:* head Guadalupe River, 1 (Amer. Mus.). *Bexar County:* San Antonio, 1. *Duval County:* San Diego, 4. *Kleberg County:* Riviera, 1 (Texas A. and I.). *Hidalgo County:* Faysville, 1 (Los Angeles Mus.). *Brewster County:* Big Bend, E. base Burro Mesa 1 (Mus. Vert. Zool.). *El Paso County:* El Paso, 1 (type).

WILLIAM B. DAVIS, *Texas Cooperative Wildlife Research Unit, College Station, Texas.*

INTRODUCTION OF FOXES INTO AN ISOLATED, CARNIVORE-FREE POPULATION: A CASE HISTORY

Harkers Island lies in Back Sound just east of Beaufort, North Carolina. It has an area of approximately four square miles; roughly half of this area is covered by salt marshes, the remainder is wooded. Physiographically the island is an old off-shore bar, lying now between the mainland and a more recent bar (Shackleford Banks). Although it is separated from the mainland by less than a mile of tide water, its off-shore origin is reflected in the absence from its fauna of a number of mainland forms. Among the missing are all members of the mammalian order Carnivora (exceptions: domestic animals and mink). Indeed, the mammalian fauna is strictly limited. Besides man and a few dogs and cats, the entire fauna consists of these species: *Didelphis virginiana;* certain bats, including at least *Nycteris borealis; Mustela vison* (limited to the salt marshes); *Mus musculus* and *Rattus rattus* (chiefly about buildings but both also occurring away from habitations); and *Sylvilagus palustris*. Until recently, the opossums were considered to be poultry pests; traps for them were set continuously about each small chicken-coop. In the tiny vegetable gardens kept by the women-folk of the fishermen, rabbits were sometimes bothersome, and were always numerous. The islanders experienced little difficulty in keeping these forms in check, however.

Into this relatively well-balanced fauna there was introduced, in the summer of 1931, two female foxes (*Urocyon*) and one male, by Wallace Guthrie, a native of the island. In the space of four years these foxes multiplied conspicuously. In another year the islanders realized suddenly that for some time past rabbits had been an unusual sight, and that opossums were no longer being caught at the chicken-coops. By 1937 the foxes

had replaced the opossums as chicken thieves and were reckoned now as exceptionally bold, often entering the chicken yards not only in broad daylight, but even in the presence of man. Rabbits now were never seen. In the winter of 1938–1939 the story enters a new phase: the foxes suddenly became less conspicuous; a few dead ones were found. There had been, obviously, a considerable decrease in their numbers.

This is the record to date as agreed to by all the natives, and as repeated to me, at different times, especially by Johnny and Charlie Russell, Willie Guthrie, Martin Fulcher, and Carl Lewis. During two-week visits on the island in the summers of 1939 and 1940, I was able to verify the present great scarcity of marsh rabbits, although I found them abundantly, at about the same time, on the adjacent islands. Neither rabbit nor opossum has completely vanished, however, and, although it may be doubtful if the island affords a sufficiently large area for the permanent support of a breeding stock of foxes, we shall have to wait a few years more to see what sort of equilibrium will be reached.—William L. Engels, *Department of Zoology, University of North Carolina, Chapel Hill, North Carolina.*

BLACK BEAR FEEDS ON "HONEYDEW" AND MAGNOLIA LEAVES

On July 24, 1940, along a deer trail in Allegany State Park, New York, a peculiarly broken branch, the top from a small, nearby cucumber tree (*Magnolia acuminata* L.) was noted. The green foliage had been almost completely eaten away and upon the bark of the tree were deep, recent lacerations made both by the claws and by the teeth of a black bear (*Euarctos a. americanus* Pallas). Near the tree were large bear scats. After making a careful examination of all the evidence, what had happened was clear.

An old injury just above the ground had somewhat weakened the base of the magnolia. The tree had also been attacked by the magnolia scale (*Neolecanium cornuparvum*), and as the infestation had been quite heavy this year, a copious secretion of "honeydew" from the scales had fallen, completely covering the leaves with the sweet, sticky substance. A black bear which discovered the "honeydew," attempted to climb the tree, but due to the weight of the bear and the old injury at the tree base, the cucumber had twisted and given way, bringing the bear to the ground, and leaving the tree in a semi-prostrate position where the bear could reach all the leaves. He had then gone along the whole tree and had eaten off all, or the greater part, of each leaf. Since this had happened a week or ten days previously, the new, rapidly growing, young leaves were already orienting themselves to the new semi-prostrate position of the tree.

To get fruit, bears do considerable damage in this region by bending and breaking the limbs and the tops of choke cherries (*Prunus virginiana* Ehrh.), pin cherries (*Prunus pennsylvanica* L.), apples (*Pyrus malus* L.), and shadberries (*Amelanchier canadensis* L.). This is, however, the first case noted of damage to a tree for the "Honeydew."—Albert R. Shadle, *University of Buffalo, Buffalo, New York.*

MID-SUMMER FOOD OF GRAY SQUIRRELS

On July 8, 1940, a female gray squirrel (*Sciurus carolinensis leucotis* (Gapper)) was collected at 6:30 p.m. at Amherst, Massachusetts. The stomach was well filled and an examination of the contents revealed that approximately 85 per cent of the mass by volume consisted of cultivated cherries. There was no evidence of cherry pits. The remainder of the contents was too finely triturated to be identified. The weight of the stomach contents was 60.5 grams, a trifle over two ounces, and occupied 70 cc. of space.

Another female collected at 7:30 p.m. on July 18, 1940, near the same location proved to be pregnant. Her stomach contents by volume consisted of approximately 80 per cent green apple, and the remaining 20 per cent of unknown mast-like substances. The total mass weighed 47 grams, about one and one-half ounces, and occupied 55 cc. of space.

These two observations indicate that gray squirrels may feed heavily upon fruit during mid-summer if fruit is available.—GORDON T. WOODS, *Ann Arbor, Michigan.*

OCCURRENCE OF BISON IN FLORIDA

The most conclusive proof that bison formerly ranged clear down to the coast of the Gulf of Mexico is contained in Vol. IX of the Publications of the Quivira Society, "Spanish Approach to Pensacola, 1689-1693." The principal references are in Document 10 recounting the journey of Don Carlos de Sigüenza y Góngora to the Bay of Pensacola. They are particularly valuable because the references are specific and because Sigüenza was Professor of Mathematics at the Royal University of Mexico and one of the most learned men of his time. In a previous communication I referred to his findings but from secondary sources. We now have his original report in translation. From this it appears that while he was exploring the eastern shores of the above bay at two points on what is now called East Bay River he came upon Indian camps. Even before reaching them, near the site of Fort Pickens on Santa Rosa Island his party reports bison tracks. At the settlements themselves, however, they found "a very tasteless stew of buffalo entrails" (p. 161), bison hair (161), other bison remains including a head (162), "a well-woven sash of buffalo hair" (167). The following from page 162 is particularly significant:

"These objects were the same sort that we had seen in the other locality but more numerous; what was peculiar here was the fact that the buffalo meat was not only half-cooked as at the other camp, but it had been pounded into very fine, evil-smelling powder in wooden mortars; there was a large quantity of all this, for the reason that on this spot or near by they had killed a buffalo; this had happened only a short while before, as the exceedingly large and frightful head was still intact. Near numerous, not badly shaped pots and pans with gourd dippers and ladles of buffalo horn in them were ten or a dozen tanned hides of this animal and uncured pelts of martens, foxes, otters, and many deer . . . . There was considerable yarn of buffalo hair, both slender and coarse, in balls and on cross-shaped distaffs of *otate* similar to the others seen."

The date of this expedition was 1693, and at the same time an expedition was sent overland from Florida starting from about the site of modern Tallahassee. The missionary who accompanied this expedition states that about a great spring (on the Chipola I think) the Indians used to camp to hunt "bear, deer, and buffalo, of which there is an abundance." (267) On or near Yellow River "some buffaloes, in crossing the stream, showed us the way" to cross (270), and on what seems to have been Blackwater River "a number of buffaloes were killed." (270) Somewhat later they came to a creek which they crossed "at a buffalo ford." (271)

Bison therefore reached practically to the coast at least between the Apalachicola River and Pensacola Bay.—JOHN R. SWANTON, *American Bureau of Ethnology, Smithsonian Institution, Washington, D. C.*

HAS SOREX CINEREUS A DISTINCTIVE NESTLING PELAGE?

Dr. C. Hart Merriam (N. Amer. Fauna no. 10, p. 60, 1895) comments, as follows, upon this shrew; "A chestnut pelage or phase occurs, but is rare. Out of 20 specimens from Roan Mountain, North Carolina, only 2 are chestnut; both were collected in September."

The Museum of Vertebrate Zoology, Berkeley, California, has a shrew of this species and color. Trapped by me, in early autumn, at Newcomb, Essex County, New York, in the heart of the Adirondacks, under a massive boulder, which shielded the trap from falling leaves, this shrew had the flabby "feel" of an infant and was so small that it gave me a transient hope that it was a Hoy's shrew. This chestnut individual was the only

one among six shrews taken during a week's stay at Newcomb. It is quite possible that this autumnal coat is quickly shed after leaving the parental abode.—MORRIS M. GREEN, *Ardmore, Penna.*

HOW FAST CAN A FOX SQUIRREL RUN?

At Bull's Island, Cape Romain Refuge, South Carolina, December 14, 1940, opportunity was afforded to accurately measure the running speed of an adult fox squirrel (*Sciurus niger niger*). Refuge Superintendent Andrew H. DuPre, Harold L. Blakey, and the writer were inspecting wildlife conditions on the Island and were traveling by automobile on a level, fairly firm road leading through a grove of matured mixed growth of pines, oaks, and sweetgum when an adult fox squirrel jumped in front of the car and ran apparently at its maximum speed to its nest box nearly 200 yards distant. Speed was adjusted to keep between 15 and 20 feet behind the squirrel and the creature was pressed to its maximum by shouting and pounding on the car. At the beginning of the race the squirrel averaged 12 miles an hour, but it slowed down as it became more exhausted and by the time it left the road it was averaging but 10 miles an hour.—CLARENCE COTTAM, *Fish and Wildlife Service, Washington, D. C.*

NOTES ON CERTAIN MAMMALS OF THE MOUNTAINS OF SOUTHWESTERN VIRGINIA

The mountains of southwestern Virginia are particularly important from a point of view of the distribution of mammals in the eastern United States, because on or near those mountains (1) some species reach the southern limits of their distribution (*Napeozapus insignis*, for example); (2) other species, predominantly southern in distribution, approximate their northern limits; (3) southern geographic races of some species (*Tamias striatus*, for example) grade into northern races. Also, geographic races of a few species appear to be restricted in range to the area (*Clethrionomys gapperi maurus* Kellogg, for example). Few data on the taxonomics and ecology of the mammals of those mountains have been published, however.

The following notes are from two sources. Cady collected the specimens and provided the ecological data. Hooper identified the specimens and made the necessary comparisons. Cady's data and the specimens were collected during the months of August, September, and October, 1938. The specimens, now in the collections of the Museum of Zoology, University of Michigan, were obtained at the following localities, all in southwestern Virginia.

High Knob.—Located about three miles south of Norton, Wise County, on the Wise-Scott county line. High Knob rises about 3000 feet above sea level, is rough and rocky and is covered with dense stands of second-growth hardwoods.

Big Stone Gap.—Wise County; lies at an elevation of 1488 feet near the Powell River. The slopes and ridges surrounding Big Stone Gap support a sparse growth of vegetation. This section has been burned over repeatedly and much of the soil has been eroded away. Also, the slate and other debris that have been dumped on the mountain sides from the numerous coal mines in the area further hinder plant growth.

Black Mountain.—part of the Cumberland Mountains; lies partly in Virginia and partly in Kentucky. Specimens were collected at an elevation of 3600 feet in heavy stands of mature hardwoods and mixed pines.

Cleveland.—Russell County; situated at an elevation of about 1700 feet on the banks of the Clinch River, five miles northwest of Lebanon. A heavy growth of blue grass covers most of the surrounding rolling hills; forested areas are local and usually small in extent.

Bundy Cave and *Daugherty's Cave.*—Russell County; located near Lebanon in rolling

limestone country which contains many caves and sink-holes. The elevation is about 1800 feet.

Roaring Springs Creek.—Russell County; drains into Cedar Creek two miles east of Lebanon. Collections were made at an elevation of 1775 feet on the creek.

The locality, head of Moccasin Creek, is in Washington County, six miles south of Lebanon, Russell County.

Slemp Creek and *Sugar Grove.*—located in Smyth County a few miles southeast of Marion at elevations between 2900 and 3100 feet.

Hungary Mother Park.—south slope of Walker Mountain at about 3500 feet elevation.

The locality, Walker Mountain, refers specifically to a collecting station at an elevation of 3800 feet on Walker Mountain.

Didelphis virginiana virginiana Kerr.—A skull only from Walker Mountain. Opossum were not common in the mountainous areas of southwestern Virginia during the fall of 1938. Cady saw but one during a period of three months there.

Sorex fumeus fumeus Miller.—Four specimens, from Black Mountain, Hungary Mother Park, and Sugar Grove. Two are in rufous summer pelage and two in gray winter pelage.

Cryptotis parva Say.—Two, from Roaring Springs Creek and Sugar Grove.

Blarina brevicauda talpoides Gapper.—Nineteen, from Big Stone Gap, Cleveland, Slemp Creek, Sugar Grove, Walker Mountain, and Hungary Mother Park. These specimens agree with series of *talpoides* from southern Michigan better than with specimens of *carolinensis* from Alabama and Georgia.

Myotis lucifugus lucifugus Le Conte.—Four, from Bundy Cave. Both *Myotis lucifugus* and *Pipistrellus subflavus* were taken in the same cave; all specimens collected were males.

Pipistrellus subflavus subflavus F. Cuvier.—Five, from Bundy Cave.

Ursus americanus.—Once common in the region, black bear are now restricted to the rough mountainous terrain along the Virginia-Kentucky state line.

Tamias striatus striatus Linnaeus.—Four, from High Knob, Cleveland, and Walker Mountain. Three grade toward *fisheri* in coloration, but all resemble *striatus* from southern Georgia more than they do *fisheri* from southeastern Ohio and southern New Jersey.

Sciurus carolinensis leucotis Gapper.—One, from the head of Moccasin Creek. On the basis of its large size and pale gray coloration the specimen is referred to *leucotis*. It was compared with a series of *leucotis* from Michigan and Wisconsin and a series of *carolinensis* from Alabama, Georgia and Florida. A county game warden and the Chief Ranger of Jefferson National Forest told Cady that gray squirrels were exceptionally abundant in Jefferson National Forest in the fall of 1938. The abundance of the squirrels may well be correlated with the abundance of forest fruits of the preceding year.

Reithrodontomys humulis humulis Audubon and Bachman.—One, from Cleveland in worn summer pelage. Until additional specimens are obtained from the region it is tentatively allocated to the race *humulus*.

Peromyscus maniculatus nubiterrae Rhoads.—Ten, from Black Mountain, Sugar Grove, and Walker Mountain.

Peromyscus leucopus noveboracensis Fischer.—Twenty-nine, from Big Stone Gap, Walker Mountain, Black Mountain, Cleveland, Sugar Grove, and Hungary Mother Park. The series is intermediate in characters between *leucopus* and *noveboracensis*. The specimens average darker than *noveboracensis* from Ohio, Michigan, and New York—nearer *leucopus* from Georgia and North Carolina. In size, however, they resemble *noveboracensis*; they are perceptibly larger than the *leucopus* examined.

Neotoma magister Baird.—One, from Daugherty's Cave. Signs of these wood rats were noted along bluffs and ridges in the higher mountains and in limestone caves in the lowlands. They were most abundant in the mountains.

Synaptomys cooperi stonei Rhoads.—Five, from Cleveland, Sugar Grove, and Walker Mountain. The specimens are slightly larger than *stonei* but are similar to that race in other characters. The three largest average as follows (millimeters): Total length, 131; tail, 17.5; hind foot, 19; condylobasal length of skull, 26.0. They are near *helaletes* in size but have a narrower rostrum and paralleling zygomata.

Clethrionomys gapperi maurus Kellogg.—One, from Black Mountain.

Microtus pennsylvanicus pennsylvanicus Ord.—Eighteen, from Walker Mountain, Slemp Creek, and Roaring Springs Creek. Compared with *pennsylvanicus* from New Jersey, southeastern Pennsylvania, and coastal Maryland our specimens show larger size, darker coloration, a broader rostrum and a shorter braincase. These specimens may represent a distinct race of meadow mouse which ranges over much of the southern part of the Appalachian Mountains.

Pitymys pinetorum scalopsoides Audubon and Bachman.—Two, from Cleveland. The characters differentiating *P. p. scalopsoides* from *P. p. pinetorum* are best seen when large series of specimens are compared. Our two specimens are large (average total length, 132.5 mm, hind foot, 16.5 mm), and darker than all other specimens of *Pitymys pinetorum* at hand (from Michigan, Indiana, Ohio, New Jersey, Maryland, and South Carolina). They perhaps represent a geographic race peculiar to the southern Appalachian Mountains, but for the present are tentatively referred to *scalopsoides*.

Zapus hudsonius hudsonius Zimmermann.—One, from Sugar Grove. The specimen has the short, broad rostrum of *americanus*. Its size, color, and other diagnostic characters, however, are those of the race *hudsonius*. Two skins only at hand from Cherokee County, North Carolina, also are referable to *hudsonius*.—EMMET T. HOOPER, *Museum of Zoology, University of Michigan*, and EARL R. CADY, *Tennessee Valley Authority, Norris, Tennessee.*

AMERICAN BISON IN LOUISIANA

On March 22, 1700, Bienville and his party left the Taensa villages on Lake St. Joseph in the northeastern part of the present state of Louisiana intending to visit the Natchitoches villages close to the present town of Natchitoches on Red River. He effected his object under great difficulties experiencing constant rains and being obliged to wade through swamps for miles.

March 25 when about 15 leagues west in the direction of Columbia on the Ouachita, where the party appears to have crossed, they killed a bison. They had marched 6 leagues that day, wading all the way until they came to the edge of a prairie where they killed the animal. This must have been in the neighborhood of Winnsboro. They crossed the Ouachita March 30 and traveled in a general southwesterly direction for about 12 leagues according to their calculations when their hunters killed a bull bison, a cow, and a calf. This must have been somewhere in Winn Parish. See Pierre Margry, "Découvertes et Établissements des Francais dans l'ouest et dans le sud de l'Amérique septentrionale (1614–1754)", Paris, 1880, vol. 4, pp. 433, 436.—JOHN R. SWANTON, *Bureau of American Ethnology, Smithsonian Institution, Washington, D. C.*

KETTLE EATEN BY PORCUPINES

Recently the author and W. S. Feeney, game biologist on the Deer Research Project, visited the Rhinelander Lumbering Museum and found there an aluminum kettle that supposedly had been eaten almost in its entirety by porcupines. The remains of the

kettle carried the name of Charles Smith of Jump River, Wisconsin, as the donor, and as the teeth marks on the kettle looked authentic, Mr. Smith was contacted for details.

According to Smith, he and two of his friends had a small lumbering camp set up about 10 years ago in what is now the Mondeaux Unit of the National Forest in Taylor County. The spring break-up came so early that many things were left at camp, including this aluminum kettle, which was left outside the camp buildings with a little meat still in it.

When Smith and his companions returned early that summer, they found that the kettle was almost entirely eaten except for a portion of one side. He is of the opinion that the porcupines ate the kettle as well as the meat because of the salt that was attached to the sides of the utensil. He also reports that he has seen this happen several times before. Smith had nothing to report as to what happened to the porcupines that did the eating.—W. E. Scott, *Wisconsin Conservation Department, Madison, Wisconsin.*

LEAST WEASEL IN IOWA

On November 2, 1940, a small weasel was brought to the Davenport Public Museum, Davenport, Iowa, for identification. The animal had been captured in the St. Ambrose College Library where it had been pursuing a mouse. When brought to the museum it it was suffering from severe spasms and died in about 2 hours. I prepared the skin and skull and sent them to the Museum of Comparative Zoology for positive identification.

The weasel proved to be a specimen of the Alleghenian least weasel, *Mustela rixosa allegheniensis*, the first record of this species for the state of Iowa. The specimen is a juvenal male, rather darkly colored. About 4 mm back of the angle of either side of the jaw is a dark brown spot; otherwise the coloration is normal. The skull is normal but the brain case is globular due to the animal's immaturity. It's measurements are: Total length, 172 mm; hind foot, 22 mm; tail, 28 mm. I wish to thank Dr. Glover M. Allen, Museum of Comparative Zoology, Cambridge, Massachusetts, for making the identification.

At the present time the specimen is in the Davenport Public Museum Collection.—Thomas J. Morrissey, *921 Mississippi Ave., Davenport, Iowa.*

NOTES ON THE GRAY EASTERN CHIPMUNK

While employed as park naturalist at the Dolliver Memorial State Park in Webster County, Iowa, during the summer of 1940 I had an opportunity to study the local distribution of the gray eastern chipmunk (*Tamias striatus griseus*). The park is bounded in part by the Des Moines River and elsewhere by fertile farm land which skirts the upper edge of the steep, wooded hills leading to the river valley. Oaks and hickories cover the hillsides and upland except for small grassy areas along the boundary. Elms, maples, and ashes are common in the valley. The maximum relief is approximately 200 feet.

The chipmunks showed a decided preference for steep, wooded slopes in the vicinity of the sandstone outcrops with a north or east exposure. Exceptions were noted in Boneyard Hollow (the coolest portion of the park) where south exposures were also populated, and around the Custodian's house where conditions were more or less unnatural. Here chipmunks were also seen on a south slope. On numerous occasions these animals were observed on less steep slopes and sometimes on relatively flat land far removed from the apparently preferred sites, but in every case these populations were found to be of a temporary nature. Such animals may have been transients looking for a suitable home or individuals that had ventured beyond their usual cruising radius.

Evidently timber is required by the chipmunk. Trees and shrubs provide some food and a certain amount of protection. A survey of the major plants on fourteen areas in-

dicated that no one species was required. This rodent was not found in timber that was open enough to permit the growth of dense grass. With the exception of clipped lawns the chipmunk apparently avoids all dense grassy areas, probably because of difficulty in running through them if pursued by an enemy. Also an enemy could readily detect the movements in the grass and make a surprise attack. Plants that are well spaced and have dense foliage a few inches or more above the ground provide good travel lanes or forage grounds for these rodents. Here they can move about with a feeling of security. Rambling vines of wild grape and Virginia creeper provide good cover as long as the leaves remain on them. I found no evidence that chipmunks used the lower, moist (not wet) depressions along the streams where cover was apparently good.

In going about their business of feeding and collecting food for storage, the chipmunks are practically noiseless. I have tried on numerous occasions to detect rustling of dry leaves or other sounds as they moved about a few feet away. Even when they dug or rooted under dry leaves it was seldom that a slight sound could be heard. In going from place to place they invariably ran noiselessly along logs, large limbs, and rocks. It was only when greatly surprised that they dashed through dry leaves for the nearest hole, and at the same time warning all other nearby chipmunks with a shrill whistle. More often, in such cases, only the whistle was heard.

Some observers believe that the "chuck" or "cluck" note of the chipmunk is an expression of contentment, but this I am inclined to doubt. The difference between the low "chuck" and the rapid, high-pitched "chip" appears to be only a matter of the degree of excitement. In either case the animal appears to be disturbed by some object or sound. The "chuck" note probably tells his associates to be on guard while the "chip" may bring nearby chipmunks to immediate attention. In one instance, while watching a chipmunk quietly searching for food on the south side of Boneyard Hollow, a second chipmunk on the north side, some 150 feet away, suddenly gave a series of shrill "chips". Immediately the first animal dashed to the top of a short stub just outside a hole under a tree where he remained for about five minutes before resuming his foraging. Later when the second animal again "chipped" the first one paid little or no attention.

The light and dark stripes on the sides of the chipmunk probably aid in concealing him. I found that it was almost impossible to locate, even at close range, a chipmunk against a background of the multi-shaded forest floor until the animal moved.

The ability of the chipmunk to climb trees is well known to observers. Because of this ability and small size this rodent is capable of picking many small fruits from trees and shrubs. On one occasion I saw a chipmunk climbing about in a prickly wild gooseberry bush apparently after the fruit. Another animal was observed to climb up a perpendicular basswood to an estimated height of thirty feet where he entered a small hole. Later as he came down the tree head first, he paused for a moment and hung to the bark by his hind feet, his fore feet swinging free of the tree. This would tend to indicate that tree-climbing is probably a more common activity in the life of a chipmunk than we have realized.—David Damon, *724 Sixth St., Ames, Iowa.*

On the Names of Geographical Forms of Ochotona Pallasii Gray

In notes on that species published by G. M. Allen (Mammals of China and Mongolia, 1938), specimens from the Gobi (Gun-Burte, Uskuk and Artsa Bogdo) are referred to the form *Ochotona pallasii pallasii* Gray. The form described from Achit Nor in the Kobdo Basin in north western Mongolia is listed by the same author as *O. p. pricei* Thomas, which is quite correct as considering *pricei* only a subspecies of *pallasii*. But this scheme must be corrected *Ochotona palasii* was described from a specimen from "Asiatic Russia—Kirgisenp." For a long time the existence of a separate species of

Ochotona in the Kirghiz steppes, different from the well-known *Ochotona pusilla* seemed very doubtful to Russian zoologists.

During many years preceding the war, Kirghiz Steppes were, strange to say, seldom visited by explorers. However, during the last 10 to 15 years *Ochotona pallasii* was once more discovered, and it was made clear that a separate species of *Ochotona*, given in the recent Russian literature under the name of *Ochotona pricei* actually inhabits the eastern parts of the Kirghiz Steppes. That species forms an isolated colony, seemingly of a relict character, in the southern parts of the low Karkaralinsk Mountains, situated to the north of Lake Balkhash. This form escaped zoologists on account of the small area occupied and its sporadic distribution. It is quite certain that in the same locality Brandt's material was procured and sent to the British Museum and that this form must be considered as nominal. According to data it is well distinguished from the one inhabiting the Kobdo Basin, which must retain its subspecific name *pricei* Thomas. The eastern form (Gobi), listed by G. M. Allen as *Ochotona pallasii pallasii*, accordingly, cannot be considered as nominal and must receive another name.—V. G. Heptner, *Zoological Museum of the Moscow University, USSR.*

TWENTY-THIRD ANNUAL MEETING OF THE AMERICAN SOCIETY OF MAMMALOGISTS

The twenty-third annual meeting of the American Society of Mammalogists was held at the Field Museum of Natural History, Chicago, from June 9 to 13, 1941, with 131 members and visitors, representing 21 states, the District of Columbia, and Canada present.

PROGRAM

MONDAY, JUNE 9

9:00 *p.m.*

Meeting of the Board of Directors, Stevens Hotel

TUESDAY, JUNE 10

10:00 *a.m.*

1. Address of welcome. Karl P. Schmidt, Field Museum of Natural History.
2. Responses by E. R. Hall, California; W. J. Hamilton, New York; Rudolph Bennitt, Missouri.
3. Mammals on islands in Lake Michigan. Robert T. Hatt, Cranbrook Institute of Sciences. Slides.
4. Status of the wolf in Michigan. A. M. Stebler, Michigan Department of Conservation. (Read by title only.) Slides.
5. Notes on some Nebraskan mammals. Edson Fichter and Lloyd D. Davis, University of Nebraska State Museum. Slides.
6. Geologic and Recent changes in the mammalian fauna of Brazos County, Texas. Randolph L. Peterson, Texas A. & M. College. Slides.
7. Flying bats avoiding obstacles. Donald R. Griffin, Harvard University. Motion pictures.

2:00 *p.m.*

Annual Business Meeting of the Society

8. Role of mammalogy in the yellow fever research of the Rockefeller Foundation. Raymond M. Gilmore, American Museum of Natural History. Slides.

9. Diseases transmitted from mammals to man. William L. Jellison, Rocky Mountain Spotted Fever Laboratory. Slides.

8:00 *p.m.*

Smoker and exhibition of flash light photographs of mammals by Tappan Gregory at the Chicago Academy of Sciences.

WEDNESDAY, JUNE 11

9:00 *a.m.*

10. On the hares of Manchuria. A. S. Loukashkin, San Francisco, California. (Read by E. R. Hall.) Slides.
11. Speciation in the rodent genus Microdipodops. E. Raymond Hall, California Museum of Vertebrate Zoology. Slides.
12. Comments on the origin and relationship of the Rodentia. Ruben A. Stirton, California Museum of Paleontology. Slides.
13. The chipmunks of California. David H. Johnson, California Museum of Vertebrate Zoology.
14. Notes on small mammals in Washington and Oregon. Jane Claire Dirks, University of Illinois. Slides.
15. Growth and development in the desert deermouse, *Peromyscus eremicus*. Arthur Svihla, University of Washington. Slides.
16. The Borcher fauna, a new Pleistocene interglacial fauna from Meade County, Kansas. Claude W. Hibbard, Kansas Museum of Vertebrate Paleontology. Sides.
17. An effect on the *Peromyscus maniculatus* Rassenkreis of land utilization in Michigan. Emmet T. Hooper, University of Michigan. Slides.

2:00 *p.m.*

18. Winter reduction of small mammal populations and its probable significance. Wm. J. Hamilton, Jr., Cornell University. Slides.
19. A comparison of small mammals' home ranges in desert, grassland, and forest associations. W. Frank Blair, University of Michigan. Slides.

SYMPOSIUM ON ANIMAL POPULATIONS

20. History of population studies. Walter P. Taylor, leader, Texas Cooperative Wildlife Research Unit.
21. Estimating animal populations. Lee R. Dice, leader, University of Michigan.
22. Live trapping and marking of animals. Durward L. Allen, leader, Michigan Conservation Department. Slides.
23. Home ranges of animals. William H. Burt, leader, University of Michigan.
24. Some practical applications of mammalian population studies. Victor H. Cahalane, leader, U. S. Fish and Wildlife Service.

7:00 *p.m.*

The annual dinner of the Society was held at the Stevens Hotel, after which Emil Liers, "The Otter Man," exhibited live otters and gave an illustrated talk on his experiences in capturing, taming, and rearing otters.

THURSDAY, JUNE 12

9:00 *a.m.*

25. The age of muskrats at sexual maturity. Herbert L. Dozier and David E. Davis, U. S. Fish and Wildlife Service and Wilmette, Illinois. Slides.

26. Breeding data on Wisconsin squirrels. H. W. Mossman, University of Wisconsin. Slides.
27. Fox squirrel territories. E. J. Koestner, University of Illinois. Slides.
28. Comparison of tree cuttings of six beaver colonies. Albert R. Shadle, Alma Nauth, and Edward Gese, University of Buffalo. Slides.
29. Opossum ecology in eastern Texas. Dan W. Lay, Texas Game, Fish and Oyster Commission.
30. A metal retaining apparatus for porcupines and other mammals. Albert R. Shadle and William Ploss, University of Buffalo. Slides.
31. Notes on sea otter pups. Edna M. Fisher, Berkeley, California. Slides.
32. Strip mines as mammal habitats. Lee E. Yeager, Illinois Natural History Survey. Slides.

2:00 *p.m.*

33. Winter food habits of the short-tailed weasel in northern Minnesota. Shaler E. Aldous, U. S. Fish and Wildlife Service.
34. A comparative osteological study of Bailey's bobcat and the house cat. K. R. Kelson, University of Utah. Slides.
35. Water buffaloes and their possibilities as marshland cattle for the South. T. Y. Peary, Sarasota, Florida.
36. Experimental studies of reproduction and moulting in the weasel. Philip L. Wright, Montana State University.
37. Kodachrome slides of certain bats. H. W. Mossman, University of Wisconsin.

3:15 *p.m.*

Final Business Meeting of the Society

FRIDAY, JUNE 13

9:30 *a.m.*

A visit to the Brookfield Zoo. The party left the Stevens Hotel at 9:30 a.m. Lunch was served through the courtesy of the local committee. The party returned at 4 p.m.

At the meeting of the Board of Directors on June 9, the board recommended: that H. E. Anthony be re-elected to succeed himself for a three year term as trustee; that Gerritt S. Miller, Jr. and Ernest Thompson Seton be elected to honorary membership; that the invitation extended to the Society by the American Museum of Natural History to hold the 1942 annual meeting in New York be accepted. William B. Davis was re-appointed chairman of the Editorial Committee.

At the annual business meeting on June 10, the three recommendations (mentioned above) made by the Board of Directors were accepted.

The following officers were elected: Walter P. Taylor, President; E. Raymond Hall and A. Brazier Howell, Vice-presidents; Robert T. Orr, Recording Secretary; Emmet T. Hooper, Corresponding Secretary; Viola S. Schantz, Treasurer. Five directors were elected for the period 1941–1943 as follows: William J. Hamilton, Jr., Otis Wade, Remington Kellogg, John Eric Hill, and Victor H. Cahalane.

The Index Committee reported that the twenty year index for the Journal of Mammalogy is two-thirds complete. It is expected that it will be completed in the latter part of 1941.

It was with deep regret that the Society learned of the deaths of sixteen members, three of whom were charter (*) members: Z. B. Adams, Harry W. Atkinson, Albert R. Brand, George E. Brewer, *Dane Coolidge, W. Redmond Cross, Clifford P. Fitch, *J. H. Fleming, Carlos C. Goff, Francis R. Hagner, P. LeRoy Harwood, *Arthur H. Howell, Max Küpfer, G. K. Noble, Raymond Pearl, C. W. Stiles.

At the suggestion of President Taylor the members stood for one minute in silent tribute to the memory of the above deceased members.

The following is a summary of the report of the Corresponding Secretary:

	1939	1940	1941
New members elected at annual meeting	75	77	108
New subscriptions	20	20	24
Total gross additions to mailing list	95	97	132
Resignations	20	21	19
Death reported	12	11	16
Subscribers delinquent	39	29	30
Annual members dropped for delinquency	30	31	43
Annual members delinquent two years	36	52	66
Annual members delinquent one year	106	87	76
Total gross loss to mailing list	253	231	250
Number of honorary members	4	3	3
Number of life members	50	51	51
Number of annual members in good standing	666	718	753
Total number of delinquent members	142	139	144
Total number of members	857	908	949
Members not receiving Journal	3	3	5
Number of paid subscribers	181	189	210
Total mailing list at this date	896	958	1012

Reports of the following standing committees were read and accepted: Editorial, Life Histories and Ecology, Conservation of Land Mammals, Nomenclature.

At the final business meeting on June 12 the following resolutions were read and adopted:

Resolved that the thanks of the American Society of Mammalogists be tendered to the President, Trustees, and Staff of the Field Museum of Natural History, to the Staff of the Chicago Academy of Sciences, and to other members of the Local Committee on Arrangements for their generous hospitality and their effective arrangements contributing to the success of the 23rd annual meeting and the enjoyment of all in attendance. Be it also resolved that the thanks of the Society be extended to the Director and Staff of the Brookfield Zoo for entertaining the Society.

Whereas there is now before the House of Representatives of the United States a bill known as the Murdock Bill (H. R. 2675) and a companion bill before the Senate (S 260) to open the Organ Pipe Cactus National Monument, Arizona, to prospecting and mining;

Whereas the Organ Pipe Cactus National Monument was established to preserve for public use, education, and enjoyment the oustanding example of Sonoran desert in the United States;

Whereas the area has been prospected for generations, without producing important mines and no mines are being operated therein today;

Whereas the enactment of legislation opening this national monument to prospecting and mining under these circumstances would be a negative approach to the problems of an important and unique public reservation, which, by virtue of its situation on the international boundary between Mexico and the United States, has scientific and cultural possibilities of international importance;

Therefore, be it resolved, that the American Society of Mammalogists, comprising a membership of about 1,000 scientists and educators, at its annual conference, June 12, 1941, petitions the Congress of the United States **not** to enact the Murdock and Hayden bills, which would result in impairment of this great public reservation, but

petitions the Congress to appropriate sufficient funds to provide the protection and facilities required to put the Organ Pipe Cactus National Monument to its highest public use.

The President appointed two committees, one, consisting of H. H. T. Jackson, W. J. Hamilton, Jr., and W. B. Davis, to draw up an amendment to the By-laws of the Society that will permit the payment of dues for life membership in instalments over a designated period of time. The other, consisting of H. H. T. Jackson, W. B. Davis, W. H. Burt, and E. T. Hooper, is to consider ways and means of stimulating prompt payment of dues.

A suggestion from T. Y. Peary of Sarasota, Florida, concerning the destruction of deer and the preservation of the manatee in Florida was referred to the Committee on Conservation of Land Mammals.

REVIEWS

Cowan, Ian McTaggart. DISTRIBUTION AND VARIATION IN THE NATIVE SHEEP OF NORTH AMERICA. Amer. Midland Nat., vol. 24, pp. 505–580, 4 "plates" and 1 map. November [received January 6, 1941], 1940.

This is an account of a systematic study based on an examination of 761 specimens, nearly all skulls-alone, which the author regards as constituting "the bulk of the material in America. More than half of these specimens are incomplete or fragmentary." Alaskan sheep are referred to 2 of the 3 subspecies of the species *Ovis dalli*. The remaining sheep are assigned to 7 subspecies of *Ovis canadensis*. The ranges of 9 of the 10 kinds are shown on a distribution map. No new names are proposed; more than 20 names were found for the 10 kinds recognized by Cowan. *Nemorhoedus palmeri* Craign 1900 is omitted from the synonomy of *O. c. canadensis*. Merriam, not Lydekker, is authority for the name *O. c. mexicana*. Misspellings of personal names (Couth for Couch, and Bilding for Belding) and place names (for example, Sierra San Martir for Sierra San Pedro Mártir and Clive River for Cleve Creek) and assignment of some localities of occurrence to the wrong counties are imperfections overly common, in part perhaps the result of failure to correct typographical errors. Designation of the pelage as "wool" instead of hair may be technically incorrect. Cowan's reliance on statistical analysis, rather than personal impression, for estimating the significance of slight cranial differences is commendable and worthwhile where adequate series of specimens are available. The difficulty by either method of evaluating the features shown in small samples, as for example the two specimens of *Ovis sheldoni* Merriam, are pointed out by the author—a valuable feature because attention thereby is directed to areas from which additional specimens will be especially useful. Certainly the classification proposed by Cowan is a distinct advance over any previous systematic arrangement and in the reviewer's opinion should be adopted until sufficient reason is demonstrated for departure therefrom.—E. RAYMOND HALL.

Gabrielson, Ira N. WILDLIFE CONSERVATION. The Macmillan Company. New York, pp. XV + 1–250, 24 figs., 32 pls. cloth, $3.50. 1941.

Several books treating the topic of wildlife conservation have appeared in the last two or three years in response to an increasing public interest in the conservation and proper management of our natural resources. The recent book by Dr. Gabrielson, in the opinion of the reviewer, is by far the best that has appeared to date; he has succeeded exceptionally well in presenting a difficult and intricate subject.

Although always keeping wildlife uppermost in his mind, the author leads the reader into a discussion of the physical bases of life—sunlight, soil, water, and air—, the destructive role man has played in reducing two of the supports (soil and water) of this four-legged structure, and the resultant loss of wildlife and other renewable natural resources. Dr. Gabrielson emphasizes basic principles set forth by Teddy Roosevelt 30 or 40 years ago that all natural resources are an integral whole, so interlocked and interwoven that no single resource can be altered without producing some effect, bad or good, upon the others.

The chapters on Fur Animals, Nongame Birds and Mammals, and Predator Relationships will be of especial interest to mammalogists. To the reviewer it seems that the author deliberately chose to present only one (the destructive) side of the picture of the ecological relationships of rodents. In such a book as this it would seem that the author should conscientiously attempt to portray as well the many beneficial relationships between rodents, soils, water, other wildlife, and man's own interests. Grinnell, Green, Taylor and others have shown that the burrowing activities of rodents have decided benefits on soil, water, and vegetation; Aldous, Hamilton, and others have found that chipmunks and certain mice are instrumental in the dispersal of raspberries, blackberries, and other shrubs that provide both food and cover for certain game species and help to prevent soil erosion; tree squirrels are instrumental in aiding reforestation and the spread of forest trees; all small mammals constitute a buffer of no small measure between predators and game birds and mammals; many small mammals, such as the marmot, armadillo, and even the universally condemned pocket gopher, are of some direct benefit to more desirable species in providing refuge cites or promoting the growth of favored food plants. Taylor has shown that the prairie dog has beneficial relations to man in helping to prevent the spread of mesquite and other shrubs that tend to crowd out the grass in range lands.

Aside from a few obviously biased statements, which the reader must interpret in the light of his own experiences, this book has the highest praise of the reviewer. Here is a message well written, well illustrated, easily read, and timely.—William B. Davis.

Camp, C. L. and **V. L. Vanderhoof.** Bibliography of fossil vertebrates 1928–1933. Special paper no. 27, Geol. Soc. of America, November 20, 1940, pp. 1–503. Published by the Society. $3.50.

This publication continues the North American list from the point reached [1927] by O. P. Hay's monumental Second Bibliography and Catalogue of the fossil Vertebrata of North America, issued in 1930 by the Carnegie Institution of Washington. Literature is included for the 6-year period indicated in the title, and some earlier publications omitted by Hay are listed. The scope of the bibliography is geographically world wide and zoologically from the ostracoderms to mammals inclusive; also literature is included on those conodonts which are thought to be chordates. The five principal parts of the publication are (1) a list of serials of 42 pages; (2) author catalogue of 226 pages, (3) subject index of 41 pages, (4) systematic index of 173 pages, and (5) synopsis of classification of 15 pages. By a system of cross-references the reader can find all the literature, for the period covered, relating to any species, class, or intermediate systematic category of vertebrates. The authors have earned the gratitude of every student of fossil mammals for thus simplifying the task of locating the literature pertinent to a given subject or kind of mammal. It is gratifying to know that a second-volume covering the period 1934 to 1939 is in course of preparation.—E. Raymond Hall.

RECENT LITERATURE

[Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters]

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ADLOFF, DR. Über die Abnutzung der Zähne durch den Gebrauch und ihre Bedeutung. Zeitschr. f. Anat. u. Entwicklung., Berlin, vol. 109, no. 2, pp. 245–251. 1938.

ALLEN, GLOVER M. The Mammals of China and Mongolia. Part 2. Publ. Amer. Mus. Nat. Hist., New York, Central Asiatic Expeditions, vol. 11, pp. xxvi + [2] + 621–1350, figs. 24–75, pls. 10–20. September 3, 1940.

AMEGHINO, FLORENTINO. Los esparasodontes. Mamíferos carniveros del eoceno inferior de la República Argentina. Obras completas y correspondencia científica de Florentino Ameghino, La Plata, vol. 19, pp. 103–140. 1935.

——— Complément de l'oeuvre "Sur les édentes fossiles de l'argentine" examen critique, révision et correction de l'ouvrage de Mr. Lydekker: "The extinct edentates of Argentine" (numéro bibliographique: 93). Obras completas y correspondencia científica de Florentino Ameghino, La Plata, vol. 23, pp. 390–429. 1936. (French and Spanish.)

ANDERSON, RUDOLPH MARTIN. Mammifères de la Province de Québec. Rapport annuel Soc. Provancher d'hist. Nat. du Canada, Quebec, pp. 37–111. February 29, 1940. (New: *Clethrionomys gapperi hudsonius*. Six forms recorded in addition to those in the English edition, 1938.)

ANDRÁS, KUBACSKA. Hazánk barlangjaiból ismeretes ösgerinces maradványok és kutatásuk története. Acta biologica, Szeged, vol. 1, no. 2, pp. 115–126, pls. 7–10. 1929. (*Ursus spelaeus* and *Felis spelaea*.)

ANGHI, CSABA GEYZA V. Beiträge zur rationellen Fütterung in Gefangenschaft gehaltener Säugetiere bei Einhaltung der quantitativen Futternormen. Der Zoologische Garten, Leipzig, n. F., vol. 12, no. 1, pp. 32–38. March, 1940.

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——— Yellow haired porcupine. The Murrelet, Seattle, vol. 20, no. 3, p. 71. September–December, 1939. (*Erethizon epixanthum epixanthum*.)

——— Pacific beaver. The Murrelet, Seattle, vol. 20, no. 3, p. 71. September–December, 1939. (*Castor canadensis pacificus*.)

——— The status of wildlife in the United States. Report of the Special Committee on the Conservation of Wildlife Resources, Washington, D. C., 76th Congr., 3rd sess. Rept. no. 1203, 457 pp., illus. 1940.

——— Massdöd av tumlare *Phocaena communis*. Fauna och Flora, Stockholm, Häft 6, pp. 284–285. 1940. (A large number of porpoises suffocated when caught by rapid ice formation in Östersjön and their carcasses were cast ashore on Fårö, off N. E. Gotland.)

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——— Wisconsin mammals scarce. Outdoor Life, Denver, vol. 85, no. 4, p. 99. April, 1940.

——— Removal of front teeth in man. Nature, London, vol. 145, no. 3677, p. 631. April 20, 1940. (Review of Hrdlička, Smithson. Misc. Coll., vol. 99, no. 3.)

——— Fossil man of Monte Circeo, Italy. Nature, London, vol. 145, no. 3677, p. 629. April 20, 1940.

——— Long-tailed red fox *Vulpes macroura*. Wyoming Wild Life, Cheyenne, vol. 5, no. 5, pp. 6, 14. May, 1940.

——— Wyoming beaver problem. Wyoming Wild Life, Cheyenne, vol. 5, no. 5, pp. 11–13, illus. May, 1940.

——— Many beavers taken. Pennsylvania Game News, Harrisburg, vol. 11, no. 2, p. 17. May, 1940.

——— Manatees at the aquarium. Bull. New York Zool. Soc., vol. 43, no. 3, pp. 99–100, fig. May–June, 1940. (Good photograph of *Trichechus inunguis* from Manaos, Brazil.)

——— Deer seen in Lake County. South Dakota Conserv. Digest, Pierre, p. 11. June, 1940.

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